Charles Lyell and modern geology

Thomas George Bonney

THE CENTURY SCIENCE SERIES

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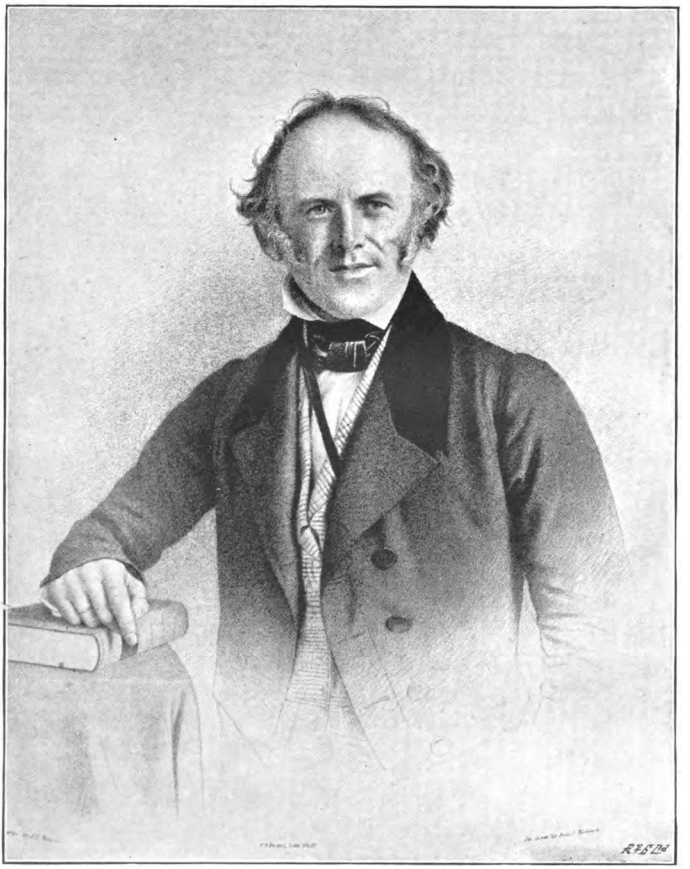

THE CENTURY SCIENCE SERIES

CHARLES LYELL

AND MODERN GEOLOGY

BY

PROF. T. G. BONNEY

D.Sc., LL.D., F.R.S., ETC.

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PREFACE.

THE life of Charles Lyell is singularly free from "moving accidents by flood and field." Though he travelled much, he never, so far as can be ascertained, was in danger of life or limb, of brigand or beast. At home his career was not hampered by serious difficulties or blocked by formidable obstacles; not a few circumstances were distinctly favourable to success. Thus his biography cannot offer the reader either the excitement of adventure, or the interest of an unwearied struggle with adverse conditions. But for all that, as it seems to me, it can teach a lesson of no little value. Lyell, while still a young man, determined that he would endeavour to put geology—then only beginning to rank as a science—on a more sound and philosophical basis. To accomplish this purpose, he spared no labour, grudged no expenditure, shrank from no fatigue. For years he was training himself by observation and travel; he was studiously aiming at precision of thought and expression, till "The Principles of Geology" had been completed and published. But even then, though he might have counted his work done, he spared no pains to make it better, and went on at the task of improvement till the close of his long life.

My chief aim, in writing this little volume, has been to bring out this lesson as strongly and as clearly

as possible. I have striven to show how Charles Lyell studied, how he worked, how he accumulated observations, how each journey had its definite purposes. Accordingly, I have often given his words in preference to any phrases of my own, and have quoted freely from his letters, diaries, and books, because I wished to show exactly how things presented themselves to his eyes, and how ideas were maturing in his mind. Regarded in this light, Lyell's life becomes an apologue, setting forth the beneficial results of concentrating the whole energy on one definite object, and the moral grandeur of a calm, judicial, truth-seeking spirit.

In writing the following pages I have, of course, mainly drawn upon the "Life, Letters, and Journals," edited by Mrs. Lyell; but I have also made use of his books, especially the "Principles of Geology," and the two tours in North America. I am under occasional obligations to the excellent life, contributed by Professor G. A. J. Cole to the "Dictionary of National Biography," and have to thank my friend Professor J. W. Judd for some important details which he had learnt through his intimacy with the veteran geologist. He also kindly lent the engraving (executed in America from a daguerreotype) which has been copied for the frontispiece of this volume.

T. G. BONNEY.

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anointed High Priest and King, after the order of Melchisedec; only begotten, first born son.

Thus far for the preface on the subject of Melchisedec, showing that he was none other than Shem, the son of Noah. We shall now give the same author's views of the same *supposed* mysterious *character*, Melchisedec, as found in his notes on the 7th Hebrews, commencing at the third verse.

Without father, without mother, without descent, having neither beginning of days, nor end of life. "The object of the Apostle, in thus producing the example of Melchisedec, was to show, 1st. That Jesus was the person prophesied of in the 110th Psalm, which Psalm the Jews uniformly understood as predicting the Messiah. 2. To answer the objections of the Jews against the legitimacy of the priesthood of Christ, arising from the stock from which he proceeded. The objection is this: if the Messiah is a *true priest*, he *must* come from a legitimate stock, as all the priests under the law have regularly done; otherwise we cannot acknowledge him to be a priest.

"But Jesus of Nazareth has not proceeded from such a stock; therefore we cannot acknowledge him for a priest, the antetype of Aaron. To this objection the Apostle answers, that it was not necessary for the priest to come from a particular stock; for Melchisedec was a priest of the Most High God, and yet was not of the stock either of Abraham (for Melchisedec was before Abraham,) or Aaron, but was a *Gentile.*

"It is well known that the ancient Jews, or Hebrews, were exceedingly scrupulous in choosing their *high priest;* partly by divine command, and partly from the tradition of their common ancestors, who always considered this office to be of the highest dignity. 1st. God commanded, (*Leviticus* xxi. 10,) that the high priest should be chosen from among their brethren; that is, from the family of Aaron. 2d. That he should marry a virgin. 3d. He must not marry a widow. 4th. Nor a divorced person. 5th. Nor a harlot. 6th. Nor one of another nation. He who was found to have acted contrary to these requisitions, was, *jure divino*, excluded from the pontificate, or eligibility to hold that office.

"On the contrary, it was necessary that he who desired this honor should be able to prove his descent from the family of

Aaron; and if he could not, though even in the priesthood, he was cast out, as we find from Ezra ii. 62, and Nehemiah vii. 63. To these divine ordinances the Jews have added, 1st. That no *proselyte* could be a priest. 2d. Nor a slave. 3d. Nor a bastard. 4th. Nor the son of a Nithinnim; these were a class of men who were *servants* to the priests and Levites, (not of their tribe,) to draw water, and to hew wood. 5th. Nor one whose father exercised any *base trade.*

"And that they might be *well* assured of all this, they took the utmost care to preserve their genealogies, which were regularly kept in the archives of the temple. When, if any person aspired to the sacerdotal function, his genealogical table was carefully inspected, and if any of the above blemishes were found in him, he was rejected."

But here the matter comes to a point as it respects our inquiry respecting Melchisedec's having no father or mother.

"*He who could not* support his pretensions by just genealogical evidences, was said to be *without father.* Thus in *Bereshith Rabba*, sec. xviii. fol. 18, are these words: *For this cause shall a man leave father and mother.* It is said, if a proselyte to the Jewish religion have married his own sister, whether by the same father or by the same mother, they cast her out, according to Rabbi Meir. But the wise men say, if she be of the *same mother*, they cast her out; but if of the same father, they retain her, *shein ab la gai*, for a Gentile *has no father;* that is, his father is *not* reckoned in the Jewish genealogies."

In this way, both Christ and Melchisedec were without father and without mother, had neither beginning of days, descent of lineage, nor end of life in *their* books of genealogies, which gave a man a right to the priesthood, as derived from Aaron; that is, were not descended from the original Jewish *sacerdotal* stock; yet Melchisedec, who was a Gentile, was a priest of the Most High God. This sense SUIDAS* confirms, under the word Melchisedec, where, after stating he reigned a prince in Salem, (that is, Jerusalem,) 113 years, he died a righteous man. To this he adds:— "He is, therefore, said to be without *descent* or *genealogy*, because

* Suidas, a Greek scholar of eminence, who flourished A. D. 975, and was an ecclesiastical writer of that age.

he was not of the seed of Abraham, (for Abraham was *his* seed) but of Canaanitish origin."

We think this sufficient to show the reason why he is said to have had no father or mother, beginning of days, nor end of life, as stated in Hebrews. But this is not said of him in the book of Genesis, where we first become acquainted with this truly wonderful character.

It should be recollected that the Jewish genealogies went no farther back, for the qualifications of their priestly credentials, or eligibility to the pontifical office, than to the time and family of Aaron, which was more than four hundred years after that of Abraham and Melchisedec. No wonder, then, that Christ's genealogy was not found in their records, so as to give him a claim to that office, such as they might approve.

But inasmuch as Melchisedec was greater than Abraham, from whom the Jewish race immediately originated, he argues from the authority of the 110th Psalm, where Melchisedec is spoken of, which the Jews allowed to be spoken of Christ, or the Messiah, who was to come, and was, therefore, a priest after the order of that extraordinary Prince of Peace, and King of Salem; because, neither had he such a claim on the Jewish genealogies, as required by the Jews, so as to make him eligible to *their* priesthood, for they knew, or might have known, that Christ did not come of the Aaronic race, but of the line or tribe of Judah.

That he was a man, a mere man, born of a woman, and came into the world after the ordinary manner, is attested by St. Paul's own extraordinary expression. *(See Hebrews*, vii. 4.*)* "Now consider how great this MAN was, unto whom Abraham gave the tenth of the spoils." However wonderfully elevated among men, and in the sight of God; however powerful and rich, wise, holy, and happy; he was, nevertheless, a mere *man*, or the tenth of the spoils he would not have received.

But the question is, what man was he, and what was his name? "Now consider how *great* this man was," are words which may possibly lead us to the *same* conclusion, which we have quoted from the preface of the book of Job.

There are not wanting circumstances to elevate this man, on the supposition that he was Shem, in the scale of society, far above a common level with the rest of the inhabitants of his coun-

try, of sufficient importance to justify St. Paul in saying, "now consider how great this man was."

We shall recount some of the circumstances; and first, at the time he met Abraham, when he was returning from the slaughter of the kings who had carried away Lot, the half brother of Abraham, with all his goods, his wife and children, and *blessed* him; he was the *oldest* man then on the earth. This circumstance alone was of no small amount, and highly calculated to elevate Shem in the eyes of mankind; for he was then more than five hundred and fifty years old.

Second: He was then the only man on the earth who had lived before the flood; and had been conversant with the nations, the institutions, the state of agriculture, arts and sciences, as understood and practised by the antediluvians.

Third: He was the only man who could tell them about the location of the garden of Eden; a question, no doubt, of great curiosity and moment to those early nations, so near the flood; the manner in which the fall of Adam and Eve took place. He could tell them what sort of fruit it was, and how the tree looked on which it grew; and from Shem, it is more than probable, the Jews received the idea that the forbidden fruit was that of the *grape vine*, as found in their traditions.

SHEM could tell them what sort of serpent it was, whether an orang-outang, as believed by some, that the evil spirit made use of to deceive the woman; he could tell them about the former beauty of the earth, before it had become ruined by the commotion of the waters of the flood; the form and situation of countries, and of the extent and amount of human population. He could tell them how the nations who filled the earth with their violence and rapine, used to go about the situation of the happy garden to which no man was allowed to approach nor enter, on account of the dreadful Cherubim and the flaming sword; and how they blasphemed against the judgments of the Most High on that account.

Fourth: Shem could inform them about the progress of the ark, where it was built, and what opposition and ridicule his father Noah met with while it was building; he could speak respecting the violent manners of the antediluvians, and what their peculiar aggravated sins chiefly consisted in—what God meant when he

emerged from the sea within the memory of people still living. Here, by way of completing his work, he "hired the services of a smith to make a mark at the water's edge:—

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So he brought his journey in Scandinavia to a close, and by the end of July had reached Kinnordy, where Mrs. Lyell awaited his coming. Then he set to work to prepare a brief sketch of his investigations for the approaching meeting of the British Association in Edinburgh, and a more elaborate paper, to be communicated to the Royal Society in London, in which he set forth the reasons which had convinced him that in Sweden, "both on the Baltic and ocean side, part of that country is really undergoing a gradual and insensibly slow rise." It affects an area measuring about one thousand miles north and south, and is believed to reach a maximum at the North Cape. There it is said, but the statement needs verification, to amount to five feet in a century; at Gefle, ninety miles north of Stockholm, it cannot be more than two or three feet in the same time; while at Stockholm itself it can hardly exceed six inches. Further south, in Scania proper, as at Malmö, Skanör, Trelleborg, and Ystad, the movement is distinctly in an opposite direction.*

This paper was afterwards accepted by the Royal Society as the Bakerian lecture for the year. But the preparation of this was not Lyell's only occupa-

* "Principles of Geology," ch. xxxi. "Antiquity of Man," ch. iii.

tion. In October he had begun fossil ichthyology, was attending lectures in chemistry, and "had made some progress," as he writes to Mantell, "in a single volume which two years ago I promised Murray, a purely elementary work for beginners in geology, and which I find more agreeable work than I had expected." So his hands were pretty full. A pleasant surprise came in the closing months of the year, namely the award of one of the Royal Medals by that Society in acknowledgment of the merits of his "Principles of Geology."

In the earlier part of 1835 Lyell accepted the presidency of the Geological Society, an office which, it will be remembered, he had virtually refused a couple of years before, when he was busy with his great book. With this exception, nothing worthy of record appears to have happened in the first six months of the year, but in July Mrs. Lyell and he left England for a journey to France, Germany, and Switzerland. By that date, as he mentions in a letter to a friend, 1,750 copies of the last edition of the "Principles" had been sold, a demand that puts him in good heart as to the future of the book, and proves that his labours on it had not been in vain. But he did not permit himself to be idle. As a letter written to Sedgwick from Paris shows, he was still working away at the classification of the Tertiary deposits; for in this letter he discusses the relation of the coralline and the red, or shelly Crag of Suffolk. Mr. Charlesworth, subsequently well known as a collector, had been obtaining a number of fossil shells from the former deposit, and the character of these suggested that it was distinctly the older of the two, as is now universally admitted. In discussing

this question Lyell lays down a principle of classification the soundness of which has been proved by experience, namely, that the age of a Tertiary deposit is to be determined by the proportion of recent species and the relation of these to the forms still living in the neighbouring seas. If, for instance, the recent shells in a formation, amounting to one-half, or even as few as one-third, of the total number can be thus found, the formation will be Pliocene in age, "while the recent shells of the Miocene have a more exotic and tropical form." To this conclusion he had been led, by an examination, with the help of Deshayes, of a typical collection of Crag fossils which he had carried with him to Paris. As to other matters, the leading French geologists were still warring vigorously in defence of deluges, and none of his numerous heresies, he remarks, appears "to have excited so much honest indignation as his recent attempt to convey some of the huge Scandinavian blocks to their present destination by means of ice." He had proved, he reminds Sedgwick, that "some of the great blocks near Upsala must have travelled to their present destination since the Baltic was a brackish water sea, so that those who maintain that there was one, and one only, rush of water, which scattered all the blocks of Sweden and the Alps, must make out this catastrophe to be, as it were, an affair of yesterday." Geology, even at that date, had advanced far enough for this admission to have landed the diluvialists in some awkward dilemmas, to say nothing of the physical difficulties which they would find in accounting for the existence of waves or currents potent enough to bowl the *Pierre à bot* from the aiguilles round the Trient glacier to the

slopes of the Jura, or to fling the erratics of Scandinavia broadcast over the lowlands around the Baltic. This, however, was not the only lost cause over which the French geologists were holding their shield. Lyell goes on to write, with a touch of quiet sarcasm: "As to the elevation crater business, Von Buch, de Beaumont, and Dufresnoy are to write and prove that Somma and Etna are elevation craters, and Von Buch himself has just gone to Auvergne to prove that Mont Dore is one also."

Lyell's special intention in visiting the Alps was to obtain evidence as to the relation of the metamorphic and sedimentary rocks. Geologists of the Wernerian School, with sundry others who hardly went so far as the Freiberg professor, maintained that the crystalline schists, including gneiss, had been produced, often as precipitates, in a primæval ocean, the waters of which were far too hot to allow of the existence of life. At a later time, as the temperature fell, the great masses of slightly altered slates and grits were deposited—the region of "greywacke," the transitional rocks as they were commonly called. These for the most part were unfossiliferous, at any rate in their earliest stages. To this view, of course, the Huttonian dictum, which Lyell sought to establish, was diametrically opposed, viz. that the earth showed no signs of a beginning. Now he had been informed that in the Alps certain slaty rocks contained fossils which indicated an age corresponding generally with the chalk of England, and that in other parts of that chain even crystalline schists could be found interbedded with fossiliferous strata of Secondary age. To settle the former question he intended to visit the famous quarries of Glarus,

but was ultimately compelled to leave this for another year, as he took the latter point first in order of time, and the investigation of it involved more work than he had anticipated. In regard to this, the most important sections were to be found on the precipitous northern slopes of the Jungfrau and in the upper part of the Urbach-thal, a lonely glen which descends into the main valley of the Aar at Imhof, above Meyringen. In both these localities gneiss appears to overlie "fossiliferous limestone," and Lyell, after visiting them, returned satisfied that he had seen "alternations of the gneiss with limestone of the lias or something newer in the highest regions of the Alps." That undoubtedly he saw, but he did not suspect that the appearance was illusory. This was not in the least surprising; the Alps were still almost a *terra incognita;* the processes of "mountain making" as yet were unknown; many statements in common currency as to the passage of sedimentary into crystalline rocks were erroneous and distinctly misleading. Only by degrees was it discovered that this superposition of gneiss or crystalline schist to Secondary rock was due to folding on a scale so gigantic that the older had been doubled over upon the younger rock and the apparent order of succession was the converse of the true one. The intercalation also of the gneiss and the Jurassic limestone was a result of a similar action, but carried, if possible, to an even greater extreme, for here the hard gneiss had been thrust in wedge-like slabs between the softer masses of sedimentary rock, like a paper-knife between the leaves of a book; that is to say, the gneiss and crystalline schists in both cases were vastly more ancient than the fossiliferous limestone. It is only of

late years that this startling fact has been established beyond question; and even now there are many geologists who do not appear to recognise how seriously the Huttonian *dictum* "there is no sign of a beginning" has been shaken by the collapse of this evidence. At the present time the question is in this position; all the attempts to prove crystalline schists to be of the same age as, or younger than, fossiliferous sedimentary rocks either have been complete failures or have proved to be very dubious, while in many cases these schists are demonstrably earlier than the oldest rocks of the district to which a date can be assigned. Hence, though possibly it may turn out that the disciples of Hutton were right, and that, as Lyell thought, a metamorphic rock may be of almost any geological age, his hypothesis not only is unproved, but also the evidence which has been brought forward in its favour has turned out after a strict scrutiny to be exceedingly dubious, if not absolutely contrary. In regard to this question we may feel a little surprise that one difficulty did not occur to Lyell's sceptical mind, namely: what could be the nature and cause of a process of metamorphism which could convert one sediment into a crystalline schist—changed practically past recognition—and leave its neighbour so far unaltered that its characteristic fossils could be readily recognised?

But though he was unable to investigate the question of Secondary or perhaps early Tertiary fossils in the "transition"-like rock of Glarus, his study of the sedimentary deposits of the Bernese Oberland, which had formed a necessary preliminary to the other inquiry, raised some difficulties in his mind as

to the origin of slaty cleavage. At a meeting of the Geological Society in the month of March, Professor Sedgwick had read his classic paper* on this subject, in which he established the independence of cleavage and bedding. This paper laid the foundation for the discovery of the true cause of the former structure, though its author was unable, with the information then at his command, to do more than suggest an hypothesis, which afterwards proved to be incorrect. He had shown that both the strike and the dip of cleavage-planes were persistent over large areas, and that while the one might gradually change its direction and the other its angle of inclination, if they were followed far enough, yet this angle usually remained unaltered for considerable distances, and appeared to be quite unaffected by any variation in the slope of the strata. From these observations it followed that the planes of cleavage ought not to be coincident with those of bedding. Lyell, however, writes to tell Sedgwick† :—

"I found the cleavage or slaty structure of fine drawing slate in the great quarry of the Niesen, on the east [south] side of the Lake of Thun, quite coincided with the dip of the strata ascertained by alternate beds of greywacké . . . . As it is the best description of drawing slate, and as divisible almost as mica into thin plates, I cannot make out how to distinguish such a structure from any which can be called slaty, and such an attempt would, I fear, involve the subject in great confusion."

The observation was perfectly correct, and many like instances could be found in the Alps; neverthe-

* "On the Structure of Large Mineral Masses," etc. *Trans. Geol. Soc. Lond.*, iii. p. 461.

† Life, Letters, and Journals, vol. i. p. 460.

less, Sedgwick was right in his generalisation, and the two structures are perfectly independent, though the difficulty raised by Lyell did not disappear till the true cause of slaty cleavage was recognised—viz. that it is a result of pressure. Thus, in a region like the Alps, where the strata often have been so completely folded as to be bent, so to say, back to back, the planes of cleavage, which are produced when the rocks can no longer yield to the pressure by bending, necessarily coincide with those of bedding. Still, even in these cases, if careful search be made in the vicinity, some minor flexure generally betrays the secret, and exhibits the cleavage structure cutting across that of bedding.

The next year, 1836, flowed on, like the last, quietly and uneventfully; a fifth edition of the "Principles" was passing through the press; the "Elements of Geology" was making progress, though slowly; and Lyell's duties as President of the Geological Society, which involved the delivery of an address in the month of February and the preparation of another one for the same season in the following year, occupied a good deal of his time. The summer was spent in a long visit to his parents at Kinnordy, after which he and Mrs. Lyell made some stay in the Isle of Arran before they returned to London. The latter seemingly had been rather out of health, and this may have been the reason why a longer journey was not undertaken, but she must have found the Scotch air a complete restorative, for after her return to London in the autumn Lyell writes to his father that "everyone is much struck with the improvement in Mary's health and appearance."

But one letter, of the few which have been preserved from those written in 1836, possesses a special interest, for it expresses his ideas, at this epoch, in regard to the question of the origin of species, and indicates his freedom from prejudice and the openness of his mind. It is addressed to Sir John Herschel, then engaged in his memorable investigations at the Cape of Good Hope, who had favoured him with some valuable comments and criticisms on the Principles of Geology, and in the course of these had corrected a mistake which Lyell had made in regard to a rather difficult physical question. In referring to this, the latter remarks that the clearness of the mathematical reasoning (to quote his words) "made me regret that I had not given some of the years which I devoted to Greek plays and Aristotle at Oxford, and afterwards to law and other desultory pursuits, to mathematics." Doubtless there is hardly any better foundation for geology than a course of mathematics; at the same time, classical studies did much to give Lyell his lucidity and elegance of style, and thus to ensure the success of the "Principles of Geology."

It will be best to give Lyell's own words, for the document forms an appendix or lengthy postscript. As is incidentally mentioned, it was not in his own handwriting,* and thus probably was drawn up with rather more than usual care.

"In regard to the origination of new species, I am very glad to find that you think it probable it may be carried on through the intervention of intermediate causes. I left this rather to be inferred, not thinking it worth while to offend a certain class of persons by embodying in words what would

* The weakness of his eyes was always more or less of a trouble.

only be a speculation . . . . When I first came to the notion—which I never saw expressed elsewhere, though I have no doubt it had all been thought out before—of a succession of extinction of species, and creation of new ones, going on perpetually now, and through an indefinite period of the past, and to continue for ages to come, all in accommodation to the changes which must continue in the inanimate and habitable earth, the idea struck me as the grandest which I had ever conceived, so far as regards the attributes of the Presiding Mind. For one can in imagination summon before us a small part* at least of the circumstances which must be contemplated and foreknown, before it can be decided what powers and qualities a new species must have in order to enable it to endure for a given time, and to play its part in due relation to all other beings destined to coexist with it, before it dies out. It might be necessary, perhaps, to be able to know the number by which each species would be represented in a given region 10,000 years hence, as much as for Babbage to find what would be the place of every wheel in his new calculating machine at each movement.

"It may be seen that unless some slight additional precaution be taken, the species about to be born would at a certain era be reduced to too low a number. There may be a thousand modes of ensuring its duration beyond that time; one, for example, may be the rendering it more prolific, but this would perhaps make it press too hard upon other species at other times. Now, if it be an insect it may be made in one of its transformations to resemble a dead stick, or a lichen, or a stone, so as to be less easily found by its enemies; or if this would make it too strong, an occasional variety of the species may have this advantage conferred upon it; or if this would be still too much, one sex of a certain variety. Probably there is scarcely a dash of colour on the wing or body, of which the choice would be quite arbitrary, or what might not affect its duration for thousands of years. I have been told that the leaf-like expansions of the abdomen and thighs of a certain Brazilian Mantis turn from green to yellow as autumn advances, together with the leaves of the plants among which it seeks for

* It is "past" in the text (Life, Letters, and Journals, vol. i. p. 468), but I think this an obvious misprint.

its prey. Now if species come in in succession, such contrivances must sometimes be made, and such relations predetermined between species, as the Mantis for example, and plants not then existing, but which it was foreseen would exist together with some particular climate at a given time. But I cannot do justice to this train of speculation in a letter, and will only say that it seems to me to offer a more beautiful subject for reasoning and reflecting on, than the notion of great batches of species all coming in, and afterwards going out at once."

Early in October Charles Darwin, for whose return from his noted voyage on the *Beagle* Lyell had more than once expressed an earnest desire, arrived in England, bringing with him a large collection of specimens and almost innumerable facts, geological and biological, the fruits of his travels. The biological observations slowly ripened in Darwin's mind till they had for their final result the "Origin of Species." The geological stirred Lyell to immediate enthusiasm, for they afforded a valuable support to some of the ideas which he had put forward to the "Principles." "The idea of the Pampas going up," he writes to Darwin, "at the rate of an inch a century, while the Western Coast and Andes rise many feet and unequally, has long been a dream of mine. What a splendid field you have to write upon!" The enthusiasm evidently was not confined to words, for Darwin himself says in writing to Professor Henslow, "Mr. Lyell has entered in the *most* good-natured manner, and almost without being asked, into all my plans." * The letter to Darwin,† which is quoted above, also contains a characteristic piece of advice.

"Don't accept any official scientific place if you can avoid

* "Life of Charles Darwin," vol. i. p. 273.

† Life, Letters, and Journals, vol. i. p. 475.

it, and tell no one I gave you this advice, as they would all cry out against me as the preacher of anti-patriotic principles. I fought against the calamity of being President [of the Geological Society] as long as I could. All has gone on smoothly, and it has not cost me more time than I anticipated ; but my question is, whether the time annihilated by learned bodies ('parles affaires administratives') is balanced by any good they do. Fancy exchanging Herschel at the Cape for Herschel as President of the Royal Society, which he so narrowly escaped being, and I voting for him too ! I hope to be forgiven for that. At least, work as I did, exclusively for yourself and for Science for many years, and do not prematurely incur the honour or the penalty of official dignities. There are people who may be profitably employed in such duties, because they would not work if not so engaged."

Not very altruistic advice, it may be feared, but nevertheless bearing the stamp of practical wisdom. Committee-work and other official duties are terrible wasters of time, and thus, although often necessary and inevitable, are rightly regarded as evils. Many men, as Lyell intimates, have been seriously hindered in researches for which they were exceptionally fitted by allowing themselves to be at everyone's beck and call, and getting their days cut to shreds by meetings. So far has this gone in some cases, that the high promise of early days has been very inadequately fulfilled, and some great piece of work has been never completed. If the spirit in which Lyell writes were more frequent, the common illusion that workers in science belong to some inferior branch of the public service would be dispelled, and the business of scientific societies would sometimes run more smoothly; at any rate, it would be finished more quickly, because no one would care to waste time over splitting hairs, and hunting for knots in a bullrush.*

* It is but rarely that, so far as the writer has seen, this remark

The year 1837, like the preceding one, was spent in quiet work, though three months of the summer were devoted to a journey on the Continent. As regards the former, it is evident that the book on which he was engaged had caused him more than ordinary difficulty, for it appears to have progressed more slowly than can be explained either by the duties of the Presidential chair, which he resigned in the month of February of this year, or by any distraction caused by other scientific work. But a sentence in a letter written to one of his sisters at the beginning of May throws some light on the cause of the delay. He says, "I have at last struck out a plan for the future splitting of the 'Principles' into 'Principles' and 'Elements' as two separate works, which pleases me very much, so now I shall get on rapidly."

The summer journey was to Denmark and the south of Norway, and this time Mrs. Lyell was able to bear him company. They left London early in June for Hamburg, crossing Holstein to Kiel, and travelling thence to Copenhagen. Here he set to work at once with Dr. Beck to study fossil shells, in the Crown Prince's cabinet and in the other museums of the city. Questions had arisen as to the nomenclature of various fossil species to which Lyell had referred in his book, on which Dr. Beck differed from Deshayes, so that Lyell was anxious to investigate some of the points for himself, and to see the original type-specimens in Linnæus' collection, since these, in some cases, had been wrongly identified by Lamarck and other palæontolo-

applies to the committees of scientific societies in London, but the amount of time thus wasted in the universities, judging from his own experience of one of them, is really melancholy.

gists. During a drive with the Crown Prince, he had the opportunity of examining an interesting section of the drift a few miles from Copenhagen, where it "was composed to a great depth of innumerable rolled blocks of chalk with a few of granite intermixed. Fossils were numerous in the chalk. . . . Prince Christian set four men to work, while the horses were baiting, to clear away the talus, by which I saw that the boulders of chalk were in fact in beds, with occasional layers of sand between."

On reaching Norway Lyell made several expeditions from Christiania, in the course of which he examined a clay which occupies valleys and other parts of the granite region. This, which sometimes is found more than 600 feet above sea-level, he states "is a marine deposit containing recent species of shells, such as now inhabit the fjords of Norway."

This visit to Norway gave Lyell the opportunity of dispelling some erroneous ideas as to the relation of the granite to the "transition" (or lower Palæozoic) strata. This granite he found to be intrusive into these rocks, and into the much more ancient gneiss on which they rested. The sedimentary rocks near the junction were much altered, the limestones being changed into marble, the shale into micaceous schists; the fossils being more completely obliterated in the latter than in the former case. Some remarks which he makes as to the relations of the granite and gneiss indicate the closeness and carefulness of his observations. "This gneiss . . . this most ancient rock is so beautifully soldered on to the granite, so nicely threaded by veins large and small, or in other cases so shades into the granite, that had you not known the

immense difference in age, you would be half-staggered with the suspicion that all was made at one batch." *

From Copenhagen, on their return, they went to Lübeck and drove thence to Hamburg, across the sand and boulder formation of the Baltic, and so through the north of Germany. Among these boulders Lyell recognised the red granite, which he had seen in Norway sending off veins into the orthoceratite limestones and associated Silurian rocks. This "had been carried, with small gravel of the same, by ice of course, over the south of Norway, and thence down the south-west of Sweden, and all over Jutland and Holstein down to the Elbe, from whence they come to the Weser, and so to this or near this (Wesel-on-the-Rhine). But it is curious that about Münster and Osnabruck, the low Secondary mountains have stopped them; hills of chalk, Muschelkalk, old coal, etc., which rise a few hundred feet in general above the great plain of north and north-west Germany, effectually arrest their passage. This then was already dry land when Holstein, and all the Baltic as far as Osnabruck or the Teutoberger Waldhills, was submerged." †

At the end of September they returned to London through Paris and Normandy, and the rest of the year was mainly devoted to the completion of the "Elements of Geology." Little seems to have happened in the earlier part of the next year (1838); and in the summer Lyell went northward, halting on the way, at Newcastle-on-Tyne, to attend the meeting of the British Association. Here he was made President of the Geological Section, which appears to

* Life, Letters, and Journals, vol. ii. p. 22.
† *Ibid.*, vol. ii. p. 20.

have been very successful, for he writes that the section was crowded—from 1,000 to 1,500 persons always present. The meeting, altogether, was a large one; but as the total number of tickets issued only amounted to 2,400, it seems probable that the general public was admitted more freely than is the custom at the present day. Sedgwick also on one occasion attracted a large crowd, for we are told that he delivered a most eloquent lecture "to 3,000 people on the Sea-shore." Geology, no doubt, has made great advances since that day, little more than half a century ago, but at the cost of much loss of attractiveness. It was then simple in its terminology, and fairly intelligible to people of ordinary education; now these are frightened away by papers bristling with technical terms and Greek-born words, and nothing but the prospect of a "scrimmage" would draw together 500 people to a meeting of Section C at the present day. Commonly the audience hardly amounts to one-fifth of that number. Geologists, perhaps, might consider with advantage whether a little abstinence from long words might not make the science more generally intelligible, and thus more attractive, without any loss of real precision.

The "Elements of Geology" was finally published a few weeks before the Newcastle meeting, and the work of recasting the "Principles" went on at intervals in preparation for the sixth edition, which appeared in 1840. If, in accordance with the maxim, a nation is happy which has no history, Lyell ought to have passed almost a year in a state of felicity, for nothing is recorded between September 6th, 1838, when he writes to Charles Darwin from Kinnordy, and

August 1st, 1839, when he writes to Dr. Fitton from the same place. Both these letters are interesting. The former discusses the relation of Darwin's theory of the formation of coral islands with E. de Beaumont's idea of the contemporaneity of parallel mountain chains, which has been already mentioned. One passage also throws light upon the difficulties with which the British Association in its earlier days had to contend. Some of the most influential newspapers had set themselves to write it down—needless to say, without success. Good sense sometimes is too strong even for newspapers. But Lyell thus urges Darwin*:—

"Do not let Broderip, or the *Times* or the *Age* or *John Bull*, nor any papers, whether of saints or sinners, induce you to join in running down the British Association. I do not mean to insinuate that you ever did so, but I have myself often seen its faults in a strong light, and am aware of what may be urged against philosophers turning public orators, etc. But I am convinced—although it is not the way I love to spend my own time—that in this country no importance is attached to any body of men who do not make occasional demonstrations of their strength in public meetings. It is a country where, as Tom Moore justly complained, a most exaggerated importance is attached to the faculty of thinking on your legs, and where, as Dan O'Connell very well knows, nothing is to be got in the way of homage or influence, or even a fair share of power, without agitation."

Far-reaching words, the truth of which has been demonstrated again and again during the years which have elapsed since they were written. Lyell lays his finger on the weakest spot in the nature of the true-born Briton: he is deaf to quiet reasoning, and frightened by loud shoutings.

The second letter, that of 1839, is addressed to

* Life, Letters, and Journals, vol. ii. p. 45.

Dr. Fitton, who had written for the *Edinburgh Review* a criticism of the "Principles of Geology," in which he had expressed the opinion that Lyell had insufficiently acknowledged the value of Hutton's work. From this charge Lyell defends himself, pointing out that, valuable as were Hutton's contributions to the philosophy of geology, he was by no means the first in the field—that there were also "mighty men of old" to whom he felt bound to do justice, even at the risk of seeming to undervalue the great Scotchman. He points out that Hutton's work occupies a fair amount of space in the section of the "Principles" which is devoted to an historical sketch of the earlier geologists:—

"In my first chapter," he writes, "I gave Hutton credit for first separating geology from other sciences, and declaring it to have no concern with the origin of things;* and after rapidly discussing a great number of celebrated writers, I pause to give, comparatively speaking, full-length portraits of Werner and Hutton, giving the latter the decided palm of theoretical excellence, and alluding to the two grand points in which he advanced the science—first, the igneous origin of granite; secondly, that the so-called primitive rocks were altered strata.† I dwelt emphatically on the complete revolution brought about by his new views respecting granite, and entered fully on Playfair's illustrations and defence of Hutton. . . . The mottoes of my first two volumes were especially selected from Playfair's 'Huttonian Theory' because—although I was brought round slowly, against some of

* Though undoubtedly this severance of geology and cosmogony was very helpful at the time to the progress of the former, the justice of it may be questioned; and Lyell's approval would not be endorsed by every geologist at the present day, though probably it would still commend itself to the majority.

† While this is true of many of the so-called primitive rocks, it is now generally believed that no inconsiderable portion are really abnormal or modified igneous rocks.

my early prejudices, to adopt Playfair's doctrines to the full extent—I was desirous to acknowledge his and Hutton's priority. And I have a letter of Basil Hall's, in which, after speaking of points in which Hutton approached nearer to my doctrines than his father, Sir James Hall, he comments on the manner in which my very title-page did homage to the Huttonians, and complimented me for thus disavowing all pretensions to be the originator of the theory of the adequacy of modern causes." *

In the following month Lyell attended a meeting of the British Association at Birmingham, and was invited, together with several of the leading men of science there present, to dine and spend the night at Drayton Manor, the residence of Sir R. Peel, near Tamworth. In a letter to one of his sisters, Lyell gives an interesting sketch of his impressions of the great statesman:—

"Some of the party said next day that Peel never gave an opinion for or against any point from extra-caution, but I really thought that he expressed himself as freely, even on subjects bordering on the political, as a well-bred man could do when talking to another with whose opinions he was unacquainted. He was very curious to know what Vernon Harcourt [the President for that year] had said on the connection of religion and science. I told him of it, and my own ideas, and in the middle of my strictures on the Dean of York's pamphlet † I exclaimed, 'By-the-bye, I have only just remembered that he is your brother-in-law.' He said, 'Yes, he is a clever man and

* Life, Letters, and Journals, vol. ii. p. 48.

† The Very Reverend W. Cockburn, D.D., who testified against the Association in a pamphlet entitled "The Dangers of Peripatetic Philosophy" (published in 1838). When the Association met at York in 1844, he read a paper before the Geological Section, criticising that science, and propounding a cosmogonical theory of his own. He was severely handled by Professor Sedgwick, but published his paper under the title, "The Bible defended against the British Association." This, though an exceptionally silly production, had a large sale. ("Life and Letters of Sedgwick," vol. ii. p. 76.)

a good writer, but if men will not read any one book written by scientific men on such a subject, they must take the consequences.' . . . If I had not known Sir Robert's extensive acquirements, I should only have thought him an intelligent, well-informed country gentleman; not slow, but without any quickness, free from that kind of party feeling which prevents men from appreciating those who differ from them, taking pleasure in improvements, without enthusiasm, not capable of joining in a hearty laugh at a good joke, but cheerful, and not preventing Lord Northampton, Whewell, and others from making merry. He is without a tincture of science, and interested in it only so far as knowing its importance in the arts, and as a subject with which a large body of persons of talent are occupied.*

The next year (1840) appears to have slipped away uneventfully, for only a single letter serves as a record for the twelvemonth, and that is but a short one addressed to Babbage asking him to look up one or two geological matters during a journey through Normandy to Paris. As it is dated from London on the 11th of August, this looks as if Lyell did not go during the summer farther than Scotland, where he presided over the Geological Section at the meeting of the British Association.† The earlier part of 1841 appears to have been equally uneventful; but the summer of that year saw the beginning of a long journey and the opening of a new geological horizon, for Mr. and Mrs. Lyell crossed the Atlantic on a visit to Canada and the United States.

* Life, Letters, and Journals, vol. ii. p. 51.

† Held at Glasgow, beginning September 17th. An allusion, however, during his American journey seems to imply a visit to France this year.

CHAPTER VII.

GEOLOGICAL WORK IN NORTH AMERICA.

THIS is a summary of their doings on the opposite side of the Atlantic in Lyell's own words: "In all, we were absent about thirteen months, less than one of them being spent on the ocean, nearly ten in active geological field work, and a little more than two in cities, during which I gave by invitation some geological lectures to large and most patient audiences."

To this may be added "three dozen boxes of specimens," and a mass of notes on the raised beaches of the Canadian lakes, the glacial drift, the falls of Niagara, and other questions of post-tertiary geology, as well as on the tertiary, cretaceous, coal, and older rocks. These afterwards produced a crop of about twenty papers, which appeared in various scientific periodicals. The principal results and the general impressions of the journey were worked up into a book entitled "Travels in North America," which was published in 1845.

A geologist who has been trained among the scenery of Britain finds his first view of the Alps to be the beginning of a new chapter in the Book of Nature, but a visit to America more like the beginning of a new volume. There almost everything is on a colossal scale—rivers, lakes, forests, prairies, distances, such as cannot be matched, at any rate in the more accessible parts of Europe. One may read of plains where the sun rises and sets as from a sea; of lakes,

like Superior, as big as Ireland; of falls, like Niagara, where the neighbouring ground never ceases to quiver with the thud of the precipitated water; of rivers well nigh half a league wide while their waters still are far from the sea. But such things must be seen to be realised. In our own island Nature seems to be working at the present time on a scale comparatively puny; she must be watched as she puts forth her full strength before the adequacy of modern causes can be duly appreciated, and the history of the past can be understood by comparing it with that of the present.

The invitation to cross the Atlantic hardly could have reached Lyell at a more opportune epoch of his life. In his forty-fourth year, he was in full vigour both of mind and of body. A long course of study and of travel in Europe had trained him to be a keen observer, had enabled him to appreciate the significance of phenomena, and had supplied him with stores of knowledge on which he could draw for the interpretation of difficulties. America also offered a splendid field for work. Much of the country had been settled and brought under cultivation at no distant date; new tracts were being made accessible almost daily. Geologists of mark were few and far between, so that large areas awaited exploration, and in many places the traveller found a virgin field. The Geological Survey of Canada was just then being organised, the labours of the National Survey in the United States had not yet begun, though State surveys were at work, and had already borne good fruit. Indeed, while Lyell was in the country, the third meeting of the Association of American Geologists

was held at Boston, and among those present were several men whose names will always occupy an honoured place in the history of the science. Still, at almost every step the observer might be rewarded by some discovery or by some fascinating problem which would give a direction to his future work.

The Lyells left Liverpool on July 20th, 1841, and reached Halifax on the 31st of the month, whence they went on to Boston, arriving there on August 2nd. The close resemblance of the shells scattered on the shore at the latter place to those in a similar situation in Britain was one of the first things which Lyell noted; for he found that about one-third were actually identical, a large number of the remainder being geographical representatives, and only a few affording characteristic or peculiar forms. For this correspondence, which, as he writes, had a geological significance, he was not prepared. The drifts around Boston, good sections of which had been exposed in making cuttings for railways, resembled very closely the deposits which he had seen in Scandinavia. Were it not, he says, for the distinctness of the plants and of the birds, he could have believed himself in Scotland, or in some part of Northern Europe. These masses of sand and pebbles, derived generally from the more immediate neighbourhood, though containing sometimes huge blocks which had travelled from great distances, occasionally exceeded 200 feet in depth. Commonly, however, they were only of a moderate thickness, and were found to rest upon polished and striated surfaces of granite, gneiss, and mica-schist. The latter effects, at any rate, would now be generally attributed to the action of land ice, but Lyell thought

that the great extent of low country, remote from any high mountains, made this agent practically impossible, and supposed that the work both of transport and of attrition had been done during a period of submergence by floating ice and grounding bergs.

After a few days' halt at Boston, they moved on to Newhaven, where Professor Silliman showed him dykes and intrusive sheets of columnar greenstone altering red sandstone, their general appearance and association recalling Salisbury Crags and other familiar sections near Edinburgh. In this district Lyell found the grasshoppers as numerous and as noisy as in Italy, watched the fire-flies sparkling in the darkness, and had his first sight of a humming-bird, and of a wildflower hardly less gorgeous, the scarlet lobelia.

From Newhaven they went to New York, and up the Hudson River in one of the great steamers, past the noble colonnade of basalt called the Palisades, and along the winding channel through the gneissic hills to Albany. Here a geological survey had been established by the State, and its members had already done good work, which, however, was not altogether welcome to its employers, for they had dispelled all hopes of finding coal within the limits of the State. This, as Lyell says, was a great disappointment to many; but it did good in checking the rashness of private speculation, and in preventing the waste of the large sums of money which had been annually squandered in trials to find coal in strata which really lay below the Carboniferous system. The advantage to the revenues of the state by the stoppage of this outlay and the more profitable direction given to private enterprise were sufficient, Lyell remarks, "to

indemnify the country, on mere utilitarian grounds, for the sum of more than two hundred thousand dollars so munificently expended on geological investigation."

From Albany Lyell travelled to Niagara. The journey was planned in order to give him an opportunity of examining a connected series of formations from the base of the Palæozoic, where it rested on the ancient gneiss, to the coalfield of Pennsylvania; and he had the great advantage of being accompanied by one of the most eminent of American geologists, Mr. James Hall.

"In the course of this third tour," Lyell writes,* "I became convinced that we must turn to the New World if we want to see in perfection the oldest monuments of the earth's history, so far as relates to its earliest inhabitants. Certainly in no other country are these ancient strata developed on a grander scale, or more plentifully charged with fossils; and as they are nearly horizontal, the order of their relative position is always clear and unequivocal. They exhibit, moreover, in their range from the Hudson River to the Niagara some fine examples of the gradual manner in which certain sets of strata thin out when followed for hundreds of miles; while others, previously wanting, become intercalated in the series."

He observed, also, that while some species of the fossils contained in these rocks were common to both sides of the Atlantic, the majority were different; thus disproving the statement which at that time was often made—namely, that in the rocks older than the Carboniferous system the fossil fauna in different parts of the globe was almost everywhere the same, and showing that, "however close the present analogy

* "Travels in North America," chap. i.

of forms may be, there is evidence of the same law of variation in space as now prevails in the living creation."

Lyell made a thorough study of the Falls of Niagara, to which he paid a second visit before his return to England. The first view of these Falls, like the first sight of a great snow-clad peak, is one of those epochs of life of which the memory can never fade. It stirred Lyell to an unwonted enthusiasm. At the first view, from a distance of about three miles, with not a house in sight—it would be impossible, we think, to find such a spot now; "nothing but the greenwood, the falling water, and the white foam"—he thought the falls "more beautiful but less grand" than he had expected; but, after spending some days in the neighbourhood, now watching the river sweeping onwards to its final plunge, here in the turmoil of the rapids, there in its gliding, so smooth but so irresistible; now gazing at that mighty wall of 'shattered chrysoprase' and rainbow-tinted spray, which floats up like the steam of Etna; now looking down from the brink of the crags below the fall upon those rapids, where the billows of green water roll and plunge like the waves of the ocean, he "at last learned by degrees to comprehend the wonders of the scene, and to feel its full magnificence."

But, keenly as he might be impressed with the poetic grandeur of the falls, he could not forget the scientific questions which were ever present to his mind. The gorge of Niagara offered a problem for solution which had for him a special fascination. Not only did it illustrate on a grand scale the

potencies of water in rapid motion, but also it furnished data for estimating the period during which this agent had been at work. The gorge has been carved in a plateau of Silurian rock, which terminates, seven miles below the falls, in a precipitous escarpment overhanging Queenstown. There was a time when that gorge did not exist, when the river first took its course along the plateau on its way from Lake Erie, and plunged over the brink of the escarpment. The valley at first was nothing more than a shallow trench excavated in the drift which covers the surface of the country—such an one as may still be seen between Lake Erie and the falls—but the river, slowly and steadily, has cut its way back through the rocky plateau from the first site of the falls near Queenstown to their present position. The upper part of this plateau consists of a thick bed of hard limestone, but beneath this the deposits become softer; and the lowest bed is the most perishable. The water, as it plunges down, undermines the overlying rock. The gorge began at once to be developed, and it has ever since continued to retreat towards Lake Erie. Every year makes some slight change. This becomes more marked when old histories are consulted and old drawings compared with the present aspect of the scene. Father Hennepin's sketch, of which Lyell gives a copy,* rude and incorrect as it is, proves beyond all question that the changes in the neighbourhood of Table Rock have been very considerable, for it shows that on this side a third and much narrower cascade fell athwart the general course of the main mass of water. This

* "Travels in North America," chap. ii.

cascade, by the time of Kalm's* visit in 1751, had ceased to be conspicuous, and had quite disappeared before the date of Lyell's visit. The Horseshoe Fall also at the present time is less worthy of the name than it was at that date, for its symmetry has been seriously marred by a deep notch which the northern stream has cut in the more central part of the curve.† Careful inquiry convinced Lyell that the slow recession of the falls was an indubitable fact, and that its rate, on an average, was about a foot a year. As the gorge is about seven miles long, this would fix its beginning about 35,000 years ago.‡

From Niagara Falls they travelled, still in Mr. Hall's company, by Buffalo to Geneva, examining on the way some red, green, and bluish-grey marls, with beds of gypsum and occasional salt springs, which, though older than the coal measures of England, closely resembled in appearance the upper part of the New Red Sandstone of Britain. Finally, after crossing the outcrops of the Devonian system, they reached Pennsylvania, where Lyell obtained his first view of the coal measures of North America, and was no less interested than surprised to find how closely the whole series corresponded with that of Britain. He saw sandstones "such as are used for building in Newcastle or Edinburgh, dark shales often full of ferns 'spread

* See the plate in the *Gentleman's Magazine*, 1751.

† See map in "Man and the Glacial Period," by Dr. G. F. Wright (International Scientific Series), p. 338.

‡ The estimates made by geologists have varied from 55,000 years (Ellicott, in 1790) to not more than 7,000 years (United States Geological Survey, 1886). Professor J. W. Spencer, who has recently investigated the question, has arrived, by a different method, at a date practically identical with that assigned by Lyell (Proc. Roy. Soc., vol. lvi. (1894), p. 145).

out as in a herbarium,' beds and nodules of clay-ironstone, seams of bituminous coal, varying in thickness from a few inches to some yards, and, beside these, an underlying coarse grit, passing down into a conglomerate, which was very like the millstone grit of England. The underclays beneath the seam of coal were full of stems and rootlets of Stigmaria, and the sight of these confirmed him in the opinion that the coal was formed of the remains of plants which had grown upon the spot.* After examining the district, they returned to Albany, and went thence to New York and Philadelphia, picking up on the way as much geological information as was possible.

New Jersey afforded some highly interesting sections of rocks belonging to the Cretaceous system, for these, though in mineral character resembling the greensands on the eastern side of the Atlantic, contained fossils which corresponded more closely with those of the white chalk, some species being actually identical. This fact was another proof that, though there had been in past ages a general similarity in the fauna of any period, geographical provinces had existed no less than they do at the present time.

Lyell had examined, as mentioned above, the bituminous coals in the undisturbed region of Pennsylvania, the next step was to study the beds of anthracite, with the associated strata, in the folded and broken ridges of the Alleghany Mountains. In this part of his work he had the inestimable advantage of being

* This was still a moot point with geologists. Lyell refers to the confirmatory evidence which W. Logan had recently obtained in the South Wales coalfield of Britain.

guided by Professor H. O. Rogers, whose name is inseparably connected with the geology of that classic region. The Alleghanies or Appalachians consist of a series of Silurian, Devonian, and Carboniferous strata in orderly sequence, "folded" (to use Lyell's words) "as if they had been subjected to a great lateral pressure when in a soft and yielding state, large portions having afterwards been removed by denudation. The long uniform, parallel ridges, with intervening valleys like so many gigantic wrinkles and furrows, are in close connection with the geological structure," and the rocks are most disturbed on the south-eastern flank of the chain, where the folds sometimes bend over to the west; in other words, the greatest disturbances are on the side nearest to the fundamental gneiss and the basin of the Atlantic—facts which probably stand in the relation of effect and cause.

It was a surprise to Lyell, on reaching the anthracite district around Pottsville on the Schuylkill, to see "a flourishing manufacturing town with the tall chimneys of a hundred furnaces, burning night and day, yet quite free from smoke." Special contrivances, of course, are requisite to secure the combustion of anthracite, especially in household fireplaces, but he had no hesitation in declaring that he preferred the use of it, notwithstanding the stove-like heat produced, to that of the bituminous coal consumed in London, with the penalty of living in an atmosphere dark with smoke and foul with smuts.

The seams of anthracite in this district are sometimes worked in open-air excavations, but as the strata have been bent into a vertical position the beds above and below, when the anthracite has been quarried out,

are left like the walls of a fissure, and thus can be examined with the greatest ease.

Here also the "roof" of the seam proved to be a dark shale full of the usual plant-remains, among which were some British species of ferns, and the "floor" was an "underclay" containing the stems and rootlets of Stigmaria. Lyell also observed that the beds of detrital materials—sandstones, shales, etc.—were less persistent than those of coal, and that the way in which the former became thicker towards the south-east indicated that this was the direction of the ancient land region from which they had been derived. The result of his examination satisfied him that the anthracite of the Appalachians was identical in age, generally speaking, with the bituminous coal which he had previously examined, and was merely a fragment of the great continuous coalfield of Pennsylvania, Virginia, and Ohio, which lies about forty miles away to the westward.

After returning to Philadelphia Mr. and Mrs. Lyell went, *viâ* New York, to Boston, where he had been engaged to deliver a course of twelve lectures on geology at the Lowell Institute. To the courses here admission was free, but the tickets were given under certain restrictions. For Lyell's lectures about 4,500 were issued, and the class, he states, usually consisted of more than 3,000 persons. It had therefore to be sub-divided and each lecture to be repeated. The audience was composed "of persons of both sexes, of every station in society, from the most affluent and eminent in the various learned professions to the humblest mechanics, all well-dressed, and observing the utmost decorum."

At the conclusion of the lectures the Lyells travelled southwards, so that he might take advantage of the more genial climate and continue his geological work in the open air. He first halted at Richmond in Virginia, and from that place visited the Tertiary deposits in the vicinity of the James River. The more interesting of these are of Miocene age, and he observed that the fossils of Maryland and Virginia resembled those of Touraine and the neighbourhood of Bordeaux more closely than those from the coralline Crag of Suffolk, especially in the presence of genera indicative of a warm climate.

From this place they travelled across the "pine barrens"—where their train was stopped for the night by the slippery condition of the rails—to Weldon in North Carolina. Here Lyell saw the Great Dismal Swamp, a morass which extends for about forty miles from the neighbourhood of this town to Norfolk in Virginia. Like the bogs of Ireland, this marshy plain, some five-and-twenty miles across, is rather higher at the middle than at the edges. Its surface "is carpeted with mosses, and densely covered with ferns and reeds, above which many evergreen shrubs and trees flourish, especially the white cedar (*Cupressus thyoides*), which stands firmly supported by its long tap-roots in the softest parts of the quagmire. Over the whole, the deciduous cypress (*Taxodium distichum*) is seen to tower with its spreading top, in full leaf, in the season when the sun's rays are hottest, and when, if not interrupted by a screen of foliage, they might soon cause the fallen leaves and dead plants of the preceding autumn to decompose, instead of adding their contributions to the peaty mass. On the surface

of the whole morass lie innumerable trunks of large and tall trees, blown down by the winds, while thousands of others are buried at various depths in the black mire below. They remind the geologist of the prostrate position of large stems of Sigillaria and Lepidodendron, converted into coal in ancient Carboniferous rocks." *

At Charleston they had practically passed beyond the southern limit of the winter snowfall, the greatest enemy of the field-geologist, and could carry on work without fear of interruption. Here they found flowers "at the end of December still lingering in the gardens," and were in the region of the palmetto palm. Few things during this rather lengthy journey impressed Lyell more than the facility of locomotion in a district which, comparatively speaking, was a new settlement, and was still in places thinly peopled, together with the general good quality of the accommodation for travellers. In this respect they had fared much worse during the previous year, when they were travelling through some of the more populous parts of France, such as Touraine and Brittany. After a journey through the pinewoods, they reached Augusta in Georgia, where another group of Tertiary deposits invited a halt. Those belonging to the Eocene period lie further down the Savannah River, so that a journey was made for the purpose of examining them, in the course of which, near the town of the same name as the river, Lyell also saw the clay in which remains of the mastodon and of other extinct mammals had been found. The muddy beach, with the tracks of racoons and opossums, gave him some hints as to

* "Principles of Geology," chap. xliv.

the history of fossil footprints, so that on the whole very much interesting geology was the reward of a three weeks' stay in South Carolina. Then they once more turned their faces northward, and made their way, working at geology as they went, to Philadelphia, where they found themselves again in the region of colder winters at the present, and of erratic boulders as memorials of the past.

Six weeks were spent in Philadelphia, but Lyell's time was largely taken up by the delivery of a short course of lectures on geology. Pennsylvania, however, added to his experiences in another way, for the state had passed through a commercial crisis, and was unable to pay the interest on its funded debt. The soreness produced by this repudiation will not be readily forgotten, for nearly two-thirds of the stock—the whole amount of which was eight millions sterling—was held by British owners, so that the loss was felt heavily on this side of the Atlantic. In his "Travels" Lyell gives a brief history of this transaction, and discusses the political causes of a crisis which had been hardly less disastrous in America than in England.

They reached New York in the month of March, and spent several weeks there, for in that neighbourhood both the ancient crystalline rocks and the modern drift, with its erratics, afforded Lyell ample materials for study, each of these being then reckoned (and they have not ceased to be so counted) among the most difficult questions of geology. Towards the middle of April he proceeded northward, in order to examine the perplexing schists and less altered sedimentary deposits of the Taconic range, rocks which from that time to this have given ample employment to geolo-

gists. After this he found an opportunity of making use of the lessons learnt on the flats by the James River, for he went to Springfield and examined the famous footprints in the sandstone of Connecticut. As the deposit was referred to the Trias, and the footprints to birds, they were supposed to indicate the existence of this class of the animal kingdom at the beginning of the Secondary era. They have, however, now lost their special interest, since they are generally assigned to reptiles. After the middle of April was past, the travellers again reached Boston, from which city an excursion was made in order to study the Tertiary deposits of the island called Martha's Vineyard, off the coast of Massachusetts.

Returning to Philadelphia early in May, they went by Baltimore westward to the valley of the Ohio, in order to examine the undisturbed country beyond the folded district of the Alleghany Mountains. By this journey another section was, in fact, run across the great coalfield of the Eastern States, but considerably to the south of that which had been examined in the autumn of the preceding year. This proved no less interesting than the former one. At Brownsville, to take one instance only, a seam of bituminous coal, ten feet in thickness, was seen cropping out in the river cliff by the side of a large tributary of the Ohio, where it was worked by horizontal galleries. Pittsburg and other interesting localities in the neighbourhood were also visited, and then the Lyells descended the Ohio River to Cincinnati. He had thus traversed in descending order the succession of strata from the Carboniferous to the Lower Silurian or Ordovician system, which is exposed in the neighbourhood of that

town. This, however, was not the only attraction offered by Cincinnati. Some two-and-twenty miles distant is the famous Big Bone Lick in Kentucky. Here some saline springs break out on a nearly level and boggy river plain, which are still attractive to wild animals, and often in past time lured them to their death in the adjacent quagmires. Here the bones of the mastodon and the elephant, of the megalonyx, stag, horse, and bison, have all been found, some in great numbers; and the last-named animals had frequented the springs within the memory of persons who were living at the time of Lyell's visit. These bones are generally embedded in a black mud, at a depth of about a dozen feet below the surface of the creek. Lyell suggests that very probably the heavy mastodons and elephants were lost by shoving one another off the tracks and into the more marshy ground as they struggled to satisfy themselves at the springs; just as horses, cattle, and deer get pushed into the stream in thronging to the rivers on the pampas of South America.

From Cincinnati the travellers struck northward to Cleveland on Lake Erie, going across a region which at that time was still being cleared and settled, and getting an experience of that American form of travellers' torture called a corduroy road. The lake-ridges—curious mounds or terraces of water-worn materials—in the neighbourhood of Cleveland afforded a new subject for an investigation which was continued in the vicinity of Ontario. But before reaching this lake Lyell spent a week at the Falls of Niagara, revising and enlarging the work already done. During the time he investigated the buried channel which appears

to lead from the whirlpool to St. Davids, a league or so to the west of Queenstown. This was supposed by Lyell and many subsequent geologists to indicate part of an old course of the St. Lawrence, which had afterwards been blocked up by glacial drifts. It is, however, according to Professor J. W. Spencer, only a branch of a buried valley, outside the Niagara cañon and much shallower than it, which has been cut through by the present St. Lawrence, and has merely produced an elongation of the chasm at the Whirlpool.* Another series of lake-ridges was examined in the neighbourhood of Toronto. Here Lyell traced them to a height of 680 feet above the level of Ontario, seeing in all no less than eleven, some of them much reminding him of the ösar which he had examined in Sweden. In regard to these lake-ridges he writes thus :—

> With the exception of the parallel roads or shelves of Glenroy and some neighbouring glens of the Western Highlands in Scotland, I never saw so remarkable an example of banks, terraces, and accumulations of stratified sand and gravel, maintaining, over wide areas, so perfect a horizontality, as in the district north of Toronto."†

Leaving Toronto on June 18th, they descended the St. Lawrence to Montreal and Quebec. The neighbourhood of either town afforded opportunities for much interesting work, especially in the drift

* Proc. Roy. Soc. lvi. (1894), p. 146.

† The lake-ridges and raised beaches around the Great Lakes, indicating margins of the water when it stood at a higher level than now, have received much attention of late years from Canadian and American geologists. They are found to vary somewhat in level, thus indicating unequal movements of the earth's crust. References to literature prior to 1890 will be found in a paper by Professor J. W. Spencer, Quart. Jour. Geol. Soc., vol. xlvi. (1890), p. 523.

deposits; the underlying ice-worn surfaces of crystalline or Palæozoic rock reminding Lyell of what he had seen in Scandinavia. At Montreal, the great hill, which gives its name to the town built upon its lower slopes, affords some highly interesting sections. It is composed of Palæozoic limestone, which has been pierced by more than one mass of coarsely crystalline intrusive rock and cleft by many dykes of a more compact character. Near the junction with the larger intrusive masses the limestone becomes conspicuously crystalline, and the fossils disappear, just as in the cases which Lyell had already seen about the border of granite in Scandinavia. Some also of the igneous rocks now possess a further interest, for they contain nepheline, a mineral not very common. This, however, had not been recognised at the time of Lyell's visit. The limestone in some of the quarries is wonderfully ice-worn, and the overlying drifts are in many ways remarkable. Of these drifts, Lyell examined various sections, at heights of from 60 to 200 feet above the St. Lawrence, finding plenty of sea-shells,* the common mussel being in one place especially abundant. He also examined some sections of stratified drifts between Montreal and Quebec, but without obtaining any fossils, though they had been found by Captain Bayford and others. The drifts, however, near the latter city were more prolific. With their shells, indeed, he was already, to some extent, familiar, for in the year 1835 he had received a collection from Captain Bayford. This happened to

* See, for descriptions of these sections and lists of the fossils, Sir W. Dawson's "The Ice Age in Canada," chaps. vi. and vii. They occur up to 560 feet above the sea.

reach London at a time when Dr. Beck of Copenhagen was with him, and "great was our surprise," he writes, "on opening the box to find that nearly all the shells agreed specifically with fossils which, in the summer of the preceding year, I had obtained at Uddevalla in Sweden." The most abundant species were still living in northern seas, some in those of Greenland and other high latitudes; while in Sweden they were found fossil between latitudes 58° and 60° N., and here in latitude 47°. These fossil shells occur at Beaufort, about a league below Quebec, and about a quarter of a mile from the river, in deposits which have filled an old ravine in the Palæozoic rock. A laminated clay forms the lowest bed, above which comes a stratified sand, and this is followed by a clay containing boulders, each of these deposits being about twenty-five feet thick. They are without fossils, which begin with the next bed, a stratified mass of pebbly sand and loam, and become more frequent, till at last this passes into a mass nearly twelve feet thick, consisting almost wholly of the well-known bivalve *Saxicava rugosa*. This deposit was about 150 feet above the level of the sea. Afterwards, in travelling southwards from Montreal, whither he returned from Quebec, Lyell found marine shells on the border of Lake Champlain, about eighty miles from the former town. Here they occured in a loam, which was covered by a sand, and rested on a clay about thirty feet thick, containing boulders, some of them nine feet in diameter.

Lyell sums up the results of his investigations by stating that, in his opinion, the shells certainly belong to the same geological period as do the boulders, and occur both above and below beds containing erratics;

while the fundamental rocks below the drift are "smoothed and furrowed on the surface by glacial action." This effect Lyell at that time attributed to the friction of bergs grounding as they floated, but it is now referred by the majority of geologists to the action of land ice. Be this, however, as it may, the shell-bearing beds must have been deposited in the sea; so that either the land must have sunk as the ice retreated, or the latter at the time of its greatest extension must have trespassed on the domain of the sea, as it still does around parts of the Antarctic continent.

From Montreal they went, by way of Lake Champlain and over the Green Mountains, to Boston, where they arrived about the middle of July, and proceeded by steamer to Halifax. Here began the last stage of Lyell's journey, the examination of the Carboniferous system in Nova Scotia, to which work a full month was devoted. After studying the gypsum, red marl, and sandstone of the lower part of that system, which bears some resemblance to the Upper Trias (Keuper) of Britain, he crossed the Bay of Mines to Minudie, in the heart of the Nova Scotian coalfield. The cliffs by the sea-shore exhibit a fine series of sections, from the gypseous rocks up to the coal measures, uninterrupted by faults, the beds dipping steadily at an angle of nearly 30°. Sandstones, shales, and seams of coal could be seen alternating in the usual manner; and from the last-named, stumps of trees, sometimes two or three yards high, were seen in places, as at South Joggins, projecting at right angles to the surface of the bed. Of such stems he observed at least seventeen at ten different levels. The stumps never

pierced a coal-seam, but always terminated downwards either in it or in shale, and never in sandstone, thus indicating that they were a part of the vegetation from which the coal had been formed, and that it, like a peat-bog in England, required a subsoil impervious to water. Lyell also mentions that Mr. (now Sir) J. W. Dawson, who was his companion for part of the time, had found a bed of calamites in a similar position of growth.

But, in addition to much interesting work in various parts of the Nova Scotian coalfield, Lyell had the opportunity of witnessing the noted tides of the Bay of Fundy, where the difference between high and low water is as great as, if not greater than, anywhere else on the globe. On the muddy flats thus left bare he had another opportunity of studying the tracks left by various animals, marine and terrestrial; and in watching how these were hardened by the action of the sun, if they had been made near the high-water mark of spring-tides, he gained further hints for interpreting the fossil footprints of Connecticut and other countries.

On the 18th of August the Lyells left Halifax for England, thus bringing to a close a year of assiduous field-work, long journeys, and varied experiences. It was a period of the most continuous outdoor labour, and thus the most fruitful in the acquisition of knowledge which he had spent since his marriage and the publication of the "Principles of Geology"—a period comparable only with his journey, between May, 1828, and February, 1829, in France, Italy, and Sicily, though it was still longer and more fruitful, were this possible, in varied geological experiences.

He had not, indeed, seen in this part of America any volcanoes, active or extinct—of which, however, he had already examined plenty; but he had studied good and characteristic sections of almost every formation which occurred in the more eastern states of America, from the most ancient crystalline masses, the foundation stones of the continent, to the most recent fossiliferous drifts. He had travelled from a region which resembled Scandinavia to one where the climate was more like that of the north coast of Africa, and had enlarged his conceptions of the scale on which Nature worked. But, in addition, he had been afforded an opportunity of studying the social and political condition of a young and vigorous nation as it was developing, unfettered by antiquated laws and hereditary customs. To this aspect of the tour a brief reference will be made in a later chapter; now it is enough to say that the long journeying of the twelvemonth had been happily ended, without illness, without the slightest accident, without anything that could be called an adventure. This good fortune followed them to the very end, for even the homeward passage is dismissed with the brief remark that it took nine days and sixteen hours; so that it may be supposed to have been prosperously uneventful. Then in eight hours after leaving Liverpool the travellers were back once more in London.

CHAPTER VIII.

ANOTHER EPOCH OF WORK AND TRAVEL.

VERY soon after their arrival in England the travellers went north to Kinnordy, where they remained till the end of October, when they returned again to their London home. Such an accumulation of specimens and of notes as had been gathered in America made necessary a long period of labour indoors, unpacking, classifying, and arranging; while certain groups of fossils had to be repacked and sent to friends, who had undertaken to work them out. These occupations apparently detained Lyell in London till August, 1843, when he started for Ireland, indulging himself on the way with a short run in Somersetshire for some geological work around Bath and Bristol, examining more particularly the "dolomitic conglomerate," a shore deposit of Keuper age, in which the remains of saurians had been found, and the Radstock Collieries, where he spent more than five hours underground "traversing miles of galleries in the coal," and finding here, as he had done in America, the stumps of trees in an upright position and shales full of fossil ferns as "roofs" to the seams. Then, in company with Mrs. Lyell, he crossed over to Cork, where the British Association assembled on August 17th, under the presidency of the late Earl of Rosse. The meeting was well attended by scientific men, but was coldly received by the neighbourhood and county—partly, as Lyell says, because the gentry cared little for

science; partly because the townspeople, comprising many rich merchants and most of the tradesmen, were "Repealers"; "and, the agitation having occurred since we were invited, the opposite parties could never, in Ireland, act or pull together."

It was impossible to visit Cork without seeing the beauties of the lakes and mountains of Killarney; and after this a short stay was made at Birr Castle, Lord Rosse's pleasant home at Parsonstown. The huge reflecting telescope, which is now more than a local wonder, was not then completed; but the smaller one, itself on a gigantic scale, was in full working order, and already had led to grand results by "not only reducing nebulæ into clusters of distinct stars, but by showing that the regular geometric figures in which they presented themselves to Herschel, when viewed with a glass of less power, disappear and become very much like parts of the Milky Way." Thence they went northward to the coast of Antrim, to see the waves breaking upon the colonnades of basalt at the Giant's Causeway, and the dykes of that rock cutting through and altering the white chalk. Evidently the geology proved interesting, as well it might, for here Nature presents a volume of her geological history, that of the Secondary era, with only the opening and the concluding chapters, all the record from the early part of the Lias to the beginning of the Cretaceous having been torn out. The dark-tinted greensand, changing almost immediately into the pure white chalk, often presents curious colour-contrasts in a single section; while the classification of the several deposits offered a problem at which probably Lyell thought it wiser to "look and pass on."

Several of the more interesting facts observed during this trip were afterwards described in the "Elements of Geology," * among them the beds of lignite which occur in Antrim, associated with the great flows of basalt. Somewhat similar deposits were found, about seven years later, at Ardtun, in Mull, by the Duke of Argyll—a discovery which led Lyell to suggest, in later editions of the above-named work, the probability that the basalts of Antrim and of the Inner Hebrides were of the same geological age,—an inference which since then has been abundantly confirmed by the researches of Professor Judd and other geologists.

One of the most interesting sections in Scotland faces Antrim. Here, on the Ayrshire coast, between Girvan and Ballantrae, a complex of several kinds of igneous rock and a region, not a little disturbed, of "greywackes" and other sedimentary deposits present the geologist with problems more than sufficiently perplexing. At these Lyell took the opportunity of glancing, but a day's trip afforded no opportunity for any serious attempt to read the riddle. That had to be left to a later generation, and so it remained for over forty years. Something is now known about the igneous rocks, though here work still remains to be done; and the sedimentary deposits have been brought into order by the labours of Professor Lapworth. They exhibit, according to his description,† an ascending succession from the Llandeilo to the Llandovery group, and appear to be more modern than some, if not all, of the above-named igneous

* Chapters xiv. and xxix.

† "The Girvan Succession," Quart. Jour. Geol. Soc., xxxviii. (1882), p. 537.

rocks. After their brief halt in this district the Lyells went on to Forfarshire, and spent the rest of the autumn at Kinnordy.

The winter was a busy time; he was writing steadily at his "Travels in North America," and working up some of the more distinctly scientific notes into formal papers for the Geological and other societies. Thus occupied, more than a year slipped away, diversified only by a summer visit to Scotland, attending the meeting of the British Association at York, and a journey to the Haswell Colliery, Durham, together with Faraday, as commissioners to examine into the cause of a recent disastrous explosion, and see whether such accidents could be prevented. Work at the "Travels in North America" took up all Lyell's spare time during the winter, and the book was published in the earlier part of 1845.

It was only a few months old when Mr. and Mrs. Lyell again set off for another tour in America. They left Liverpool on September 4th, and landed at Halifax on the 17th, after a voyage diversified agreeably by the sight of an iceberg and disagreeably by two gales. They went on at once to Boston, and thence made a tour through the State of Maine. During this sundry masses of drift were examined, which rested on polished and grooved surfaces of crystalline rock, and contained the usual shells, *astarte*, *cardium*, *nucula*, *saxicava*, etc., and in some places a fossil fish* in concretionary nodules. At Portland similar shells had been found in drifts which also contained bones both of the bison and of the walrus. These drifts in some places attained a thickness of 170 feet, and in

* The capelin (*Mallotus villosus*), which still lives in the Atlantic.

them valleys 70 feet deep had been excavated by streams. Then they went to the White Mountains, and on approaching them Lyell did not fail to notice "on the low granite hills many angular fragments of that rock, fifteen to twenty feet in diameter, resting on heaps of sand." On their way they came to the Willey Slide, where a whole family of that name had been killed nineteen years previously in a landslip. Lyell carefully examined the scene of the accident, in order to ascertain what effects were produced by a mass of mud and stones as it slid over a face of rock, and found that it only made short scratches and grooves, not long and straight furrows, like those left by a glacier. They halted at Fabyan's Hotel near Mount Washington, and after waiting for a favourable day reached the summit (6,225 feet above the sea) on October 7th. It is easily accessible on horseback.

The notes of this excursion among the mountains show that Lyell still retained his old liking for natural history in general, for they contain remarks on the flowers, the insects, and the birds. Some observations on the Alpine flora of the higher summits in the White Mountains indicate his position at that time in regard to the origin of species. He adopts the hypothesis of 'specific centres,' viz. that "each species had its origin in a single birthplace and spread gradually from its original centre to all accessible spots, fit for its habitation, by means of the power of migration given it from the first." He supposed that the plants common to the more arctic regions and to the higher ground further south in Europe and Northern America were dispersed by floating ice during the glacial epoch, when the ground stood at a lower level, and that after-

wards, when the climate became warmer, they gradually mounted up the slopes of the hills. The possibility of a migration by land is not mentioned, though doubtless it would have been admitted, because the evidence which he had so often studied pointed rather to a downward than to an upward movement; but he asserts with some emphasis that many living species are older than the existing distribution of sea and land.

On his return to Boston, he had other opportunities of studying ice-worn rocks and erratics, and from this city made an excursion to Plymouth (Massachusetts) to see the spot where, on a mid-winter day, the Pilgrim Fathers had landed. But even here he could not neglect the shells upon the strand, and he records that eighteen species were collected, one-third of which were common to Europe. Still, we may note that on this journey rather more attention was paid than on the former to questions political, commercial, educational, and theological, and these occupy a larger space in the "Second Visit to the United States," which may account for its greater popularity. For example, it contains a sketch of the witch-finding mania in Massachusetts late in the seventeenth century, and a whole chapter on the sea-serpent. This "hardy perennial" had appeared in the Gulf of St. Lawrence in the previous August and in October, 1844,* and had repeatedly visited the New England coast from 1815 to 1825, when it had been seen by many credible witnesses. Lyell appears to be satisfied that, though allowance had to be made for exaggeration and honest

* It was also seen the following year on the coast of Virginia, and on that of Norway in both 1845 and 1846.

misconception, some big creature had been seen, and suggests that it may have been an exceptionally large specimen of the basking shark.*

After a stay of nearly two months in Boston, they left for the south early in December, and found a little difficulty at first, as on a former occasion, from the slippery state of the rails. They journeyed by Newhaven, New York, Philadelphia, and Washington to Richmond, where a halt was made to examine the coalfield some sixteen miles to the south-west of the city. The measures rest on the granite, filling up inequalities on its surface, and are occasionally cut by dykes, which produce the usual alteration in the adjacent coal. The principal seam is from thirty to forty feet thick; but the field, as a whole, reminded Lyell most of that at St. Etienne (France), which he had visited in 1843.† From Richmond they went, as on the former occasion, by Weldon to Wilmington, where the cliffs near the town yielded some Tertiary fossils, and on Christmas morning they landed from a steamer at Charleston.

From this city Lyell again visited the deposits near Savannah, which contained remains of megatherium, mastodon, and other large quadrupeds, as well as a second locality on Skiddaway Island, and then, on the last day of the year, quitted Charleston for Darien in Georgia. Here also were some more deposits of the same kind, while at St. Simon's Island Lyell examined a very large Indian mound. It was a

* He says that the alleged sea-serpent washed ashore at Stronsa (Orkneys) in 1808 is proved by the bones (some of which are preserved) to have been this animal.

† The formation, however, does not belong to the Carboniferous system, but is shown by its fossils to be Jurassic in age.

mass of shells, chiefly of oysters, and contained flint arrow-heads, stone axes, and fragments of Indian pottery.

Returning to Savannah, they travelled towards the north-west, by Macon to Milledgeville. For more than 150 miles of the first part of the journey Lyell went along the railway on a hand-car, so as to study the cuttings and obtain the most continuous section possible of the Tertiary deposits from the sea to the inland granite. These deposits consisted of porcelain clays, yellow and white sands, and "burrstone," a flinty grit used for millstones, which often was full of silicified shells and corals, with the teeth of sharks and the bones of zeuglodon. Lyell mentions that in the neighbourhood of Macon he saw blockhouses such as those described by Cooper in the "Pathfinder," which twenty-five years earlier had been used for defence against the Indians before any white men's houses had been built in the forest.

Near Milledgeville the granite, gneiss, etc., is decomposed *in situ* to a considerable depth, and the rain-water, when the trees have been cut down, quickly furrows the detrital deposits of the neighbourhood. A remarkable instance of this action had occurred at Pomona Farm, where a ravine 180 feet broad and 55 feet deep had been excavated in the course of only twenty years.* From Milledgeville they returned to Macon, and thence travelled westward by Columbus to Montgomery, being much jolted in the stage-coach, but securing as a reward some Tertiary fossils; and at the latter place they found red

* It is described and figured in later editions of the "Principles of Geology," chap. xv. (eleventh edition).

clays and sandstones, which, however, were about the same age as the chalk of England. After the coach travelling, a journey by steamer down the Alabama River to Mobile was a welcome change, and the not unfrequent halts for cargo or to take in wood gave opportunities for collecting fossils from the neighbouring bluffs. One night they were startled by loud crashing noises and the sound of breaking glass, and found that the steamer had run foul of the trees growing on the bank. Their branches touched the water, as the river was unusually high; and the vessel, in the darkness, had been steered too near to the shore. Longer halts were made at Claiborne, to collect fossils from deposits corresponding in age with those at Bracklesham in England; and at Macon (Alabama), to visit a place where some remarkable specimens of the zeuglodon had been discovered. From Mobile also a long river journey was undertaken to Tuscaloosa, to visit a coalfield which supplied the town with fuel and the materials for gas. The field, "a southern prolongation of the great Appalachian coalfield," is a large one, being about ninety miles long and thirty wide, with some seams sixteen feet thick worked in open quarries. He remarks that he made geological excursions "through forests recently abandoned by the Indians, and where their paths may still be traced."

The strata on the Alabama River afforded a useful lesson on the variability of lithological characters. Were it not for the fossils, Lyell says, the Lower Cretaceous beds of loose gravel might be taken for the newest Tertiary, the main body of the Chalk for Lias, and the soft Tertiary limestone for the representative

of the Chalk. It was impossible to leave Mobile without seeing something of the Gulf of Mexico; so they went in a steamer down the Alabama River to the seaside, looked upon the muddy banks, with the shells* which live in them and the quantities of drift-timber which bestrew them, and then went across to one of the minor mouths of the Mississippi, and, passing up it, landed at New Orleans.

This town, about 110 miles by water from the confluence of the main channel of the Mississippi with the sea, afforded a convenient opportunity for studying the character of the lower part of the delta of the "Father of Waters." Such a region might be expected to supply facts which would be helpful in the interpretation of many phenomena presented by the coal measures. Accordingly, Lyell made one excursion to Lake Pontchartrain, a great sheet of fresh water no great distance from both New Orleans and the sea, and another down to the mouth of the Mississippi. The road through the swamp to the former was constructed of a strange material—viz. the white valves of a fresh-water mollusc.† These are obtained from a huge bank over a mile in length, and sometimes about four yards in depth, at one end of the lake. How this had been formed seemed doubtful. Possibly the shells had been piled up by the waves during a storm; possibly there had been some slight change of level. The lake itself is about fifteen feet below high-water mark, and is about as many deep; but, as it receives an arm of the Mississippi, silt is gradually raising the bottom. The sea

* A species of *Gnathodon*.

† *Gnathodon cuneatus*.

sometimes, when impelled by a strong south-east wind, makes its way into the lake. Among the English coal measures—as, for instance, at Coalbrook Dale or in Yorkshire—beds of marine shells are occasionally found intercalated among or even associated with freshwater molluscs, without any alteration in the general character of the beds in which they lie. How this might occur is illustrated by Lake Pontchartrain in the swampy alluvial delta. Here a very slight physical change might enable the sea to take, for a time, possession of the land, and the denizens of its water, like a band of pirates, to dispossess the usual inhabitants.

The other expedition also supplied not a few valuable facts relating to the history of river deltas, which were afterwards supplemented as they travelled northwards for some hundreds of miles up the river, following its sinuous course through leagues of marshy plain, densely overgrown with vegetation. In the seaward reaches, reed, and rush, and willow, but above New Orleans cypresses and other timber trees, rise above the rank herbage.

The minor channels, blocked with driftwood which formed natural rafts; the sand-bars and mud-banks; the great curves of the river, the "bayous"* and isolated pools; the natural banks built up by the sediment arrested at flood-time by the herbage near the river brink; the floating timber and the "snags" —all provided valuable illustrations of the physical

* A bayou is the name given to an old channel of the river. When the latter is making a series of horseshoe curves, the stream often cuts through the neck of land which separates its nearest parts. The water then takes the shortest course, the entrances to the old channel are silted up, and it becomes a horseshoe-shaped pool.

features of a great river delta, and supplied him with material which afterwards was worked up into newer editions of the "Principles" and the "Elements."

From New Orleans Lyell went by steamer to Natchez, halting on the way to examine more closely certain localities of interest and to obtain illustrations of how a coalfield might be formed. The bluffs of Natchez—almost the first place where distinctly higher ground approaches the river-side—afforded plenty of semi-fossil shells, specifically identical with those still inhabiting the valley of the Mississippi, but the loam in which they were embedded—a loam which reminded him of the loess of the Rhine—also contains the remains of the mastodon, and overlies a clay with bones of the megalonyx, horse, and other quadrupeds, mostly extinct. Beneath this clay are sands and gravel, the whole forming a platform which rises about 200 feet above the low river plain, revealing an earlier chapter in the history of the river. Similar bluffs occur at Vicksburg, but these disclosed Eocene strata beneath the alluvial deposits, and thus invited a halt in order to explore the neighbourhood. The next stage was to Memphis, nearly 400 miles. Lyell speaks highly of the accommodation generally afforded by the river steamers, but found the inquisitiveness of his American fellow-travellers rather a nuisance, and the spoiled children a still greater one. The former drawback to pleasure has certainly abated during the last half-century, but whether the latter has done the same may perhaps be disputed. New Madrid, 170 miles above Memphis, called for a longer halt, for the neighbouring district had suffered from a great earthquake in the year 1811, when shocks were felt at intervals for about

three months, the ground was cracked, water mingled with sand was spouted out, yawning fissures opened (in one case draining a lake), portions of the river cliff were shaken down into the stream, and a large district —about 2,000 square miles in area—was permanently depressed. Some traces of the earthquake, in addition to the last-named, could still be recognised at the time of Lyell's visit, though more than thirty years had elapsed.

At Cairo, above New Madrid, the Ohio joins the Mississippi, and it was ascended to Mount Vernon. The geology now became a little more varied, for beneath the shelly loam already mentioned Carboniferous strata make their appearance, in which fossil plants are sometimes abundant and upright trees now and then occur. For nearly 200 miles higher up the Ohio, rocks of this age are exposed at intervals, till at last, near Louisville, those belonging to the Devonian system rise from beneath them. These, at New Albany, contain a fossil coral-reef, exposed in the bed of the river and crowded with specimens in unusually good preservation. At Cincinnati the travellers came at last upon old ground, and journeyed thence by steamer to Pittsburg. About thirty-two miles from this town, at a place called Greensburg, some remarkable footprints had been discovered on slabs of stone not many months before Lyell's visit, but as the beds on which they occurred belonged to the coal measures doubt had been expressed as to their being genuine, so he went thither to satisfy himself on this point. The footprints had disturbed the peace of Pittsburg, for they had started discussions in which one party had

assumed, as matters of course, the high antiquity of the earth and the great changes in its living tenants, and had thus incurred the censure—which in some cases was followed by professional injury—not only of the multitude, but also of some of the Roman Catholic and Lutheran clergy. Commenting on this episode, Lyell quotes with approbation the words of a contemporary author,* which even at the present time occasionally need to be remembered:—"To nothing but error can any truth be dangerous; and I know not where else there is to be seen so altogether tragical a spectacle, as that religion should be found standing in the highways to say 'Let no man learn the simplest laws of the universe, lest they mislearn the highest. In the name of God the Maker, who said, and hourly yet says, "Let there be light," we command that you continue in darkness!'"

The travellers crossed the Alleghany Mountains in their way to Philadelphia. But a piece of work in Virginia had been left unfinished on the last occasion—the examination of the Jurassic coalfield near Richmond. So he set off thither, leaving Mrs. Lyell in Philadelphia, and took the opportunity of examining the Tertiary deposits near the former town and the Eocene strata on the Potomac River. On his return they went to Burlington, which they reached in the first week in May, just as the humming-birds were arriving in hundreds, and by the 7th of the month they were in New York. The age of the so-called Taconic Group—a question of which so much has been heard of late years—was then beginning

* T. Carlyle ("Letter on Secular Education").

to attract attention, so Lyell went in company with some American geologists to Albany in the hope of solving the problem. This he trusted he had done, but as his conclusions now would be deemed unsatisfactory, they need not be quoted. In reality, the question at that time was not even ripe for discussion.

On the homeward journey he turned aside at Boston to visit Wenham Lake, from which much ice was being supplied to London, and then they left for England by a steam packet which touched at Halifax. Four days after leaving this place they passed among a "group of icebergs several hundreds in number. varying in height from 100 to 200 feet," many of them picturesque in form, some even fantastic. Stones were resting on one of them, but as a rule they were perfectly clean and dazzlingly white, except on the wave-worn parts, which, as usual, were a beautiful blue. These, and a fine aurora borealis on the next night, were the only incidents of the voyage, and on June 13th, in twelve and a half days from Boston, the vessel reached Liverpool.

The close of this journey marks an epoch in Lyell's life. It was the last—unless we except his visit to Madeira—of his long wanderings for the purpose of questioning Nature face to face, and of studying her under various aspects and diverse conditions. He did not, indeed, cease to travel. He twice returned to America, he revisited Sicily and various parts of Europe, but these journeys not only occupied less time but also led him among scenes for the most part not unfamiliar. He doubtless felt that on reaching his fiftieth year he might fairly regard the more laborious

part of his education completed, although he never ceased to be a learner, even to the latest days of his life, when strength had failed and memory was becoming weak.

An account of the above-named journey was published in 1849, under the title of "A Second Visit to the United States of North America." This book, in addition to descriptions of the scenery and the geology of the country, contains much general information about the people, with remarks by the author on various political questions, such as the condition of parties, the effects of almost universal suffrage, particularly on the national sense of honour and morality, the existence and evils of slavery, the state of religious feeling, the position of Churches, and the systems of education, especially when contrasted with those of England. Some of these questions about this time were exciting much attention in Great Britain, and in regard to one matter—the delimitation of the territories of the two nations in the region west of the Rocky Mountains—friction existed, which was so serious that more than once war seemed possible. On this account, probably, the "Second Visit" was a greater success, commercially speaking, than the "Travels," for it reached a third edition.

CHAPTER IX.

STEADY PROGRESS.

THE "Principles of Geology" had been completed and published for thirteen years, yet catastrophism, as we learn from a correspondence with Edward Forbes,* dated September, 1846, was dying hard. "Agassiz, Alcide D'Orbigny, and their followers [were still] trying to make out sudden revolutions in organic life in support of equally hypothetical catastrophes in the physical history of the globe."† A remark in Forbes's reply is striking:—

"You are pleased to compliment my paper on its *originality*. Any praise from you must ever be among the greatest gratifications to me, and to any honest labourer in the great field of Nature. But I had rather hear the views I have set forward be proved *not original* than the contrary. It seems to me that the surest proof of the *truth* of such conclusions as I have summed up at the end of my essay is the fact of their not being *original* so far as *one* person is concerned, and of their having become manifest to *more than one* mind, either about the same time or successively, without communication. I believe laws discover themselves to individuals, and not that individuals discover laws. If a law have truth in it, many will see it about the same time."

In this month also the Lyells removed from Hart Street to 11, Harley Street. The house where they had spent fourteen years very happily was not left without regret, but it had become too small. They

* In reference to an essay written by him on the connection between the fauna and flora of the British Isles and geological changes. ("Memoirs of the Geological Survey," i. p. 336.)

† Life, Letters, and Journals, vol ii. p. 110.

had no children, but a rapidly increasing geological collection takes up almost as much room as (though it is much more silent than) a growing family. The removal of a geological collection is a laborious business; and, besides this, Lyell was preparing a new edition of the "Principles" and writing a book about his recent travels in America. Still, to judge from his letters, he found time for some pleasant social distractions; for his letters to the old home at Kinnordy contain more often than formerly interesting references to talks with such men as Macaulay, Milman, and Rogers, Lord Clarendon and Lord Lansdowne. The seventh edition of the "Principles," condensed into a bulky single volume, was published early in 1847, and in the following June Lyell attended the meeting of the British Association at Oxford, which appears to have been no less pleasant than successful, although "out of twenty-four Heads of Houses only four were at Oxford to receive the Association." On this occasion, he writes, he became better acquainted with "Ruskin, who was secretary of our Geological Section." The remainder of this summer was spent in Scotland, and the rest of the year, with most of the following one, was devoted to quiet work. Still, Lyell took an active part in a crisis through which, about this time, the Royal Society was passing. A number of the Fellows, including most of those eminent in science, were anxious to raise the standard for admission into the Society. For many years past the "three letters" had often signified little more than an indication of good means and social position, coupled with a certain interest in scientific pursuits. The reformers prevailed, after a long

struggle "with a set of obstructives compared with whom Metternich was a progressive animal," and the present *status* of the society is the result. Incidental remarks in Lyell's letters to his relations also indicate that he was becoming well known in circles other than scientific, of which a further proof was given in the autumn of 1848, when he received the offer of knighthood. Of course, in any country where "orders of merit" exist, other than Great Britain, Lyell would have been "decorated" years ago, but we manage things differently. As a rule, we let science and literature be their own reward, and, as an exception, confer the same distinction on a man who has won a world-wide reputation (provided he is fairly rich) and on an opulent tradesman who is accidently prominent on some auspicious occasion, or is a local wirepuller in party politics. Lyell went over from Kinnordy to Balmoral to receive the intended honour, and had, as he writes, "a most agreeable geological exploring on the banks of the Dee, into which Prince Albert entered with much spirit." In February, 1849, he was elected for the second time President of the Geological Society, and in the autumn, when at Kinnordy, was again invited to Balmoral, where he had some interesting talks with Prince Albert on subjects ranging from various educational and broad political questions to the entomology of Switzerland, Scotland, and the Isle of Wight.

In the middle of September he attended the meeting of the British Association at Birmingham, where he was for the third time President of the Geological Section. A few weeks later his father, whose health had

been for some time failing, died at Kinnordy.* The latter was a rich man, but as he made liberal provision for his daughters and younger sons, Sir Charles, though he succeeded to a considerable estate, found himself unable to afford the expense of keeping up Kinnordy as well as a house in London. Which, then, was henceforth to be his home? The attractions of Kinnordy were obvious, but the long distance from the metropolis was a serious drawback, while the duties of a resident landlord would have interfered much with his geological work, which would have been still more hampered by the severance from libraries, museums, and intercourse with fellow-workers. Thus he felt it his duty to retain his house in London and to let Kinnordy, though, as his mother and sisters retreated to the "dower house," he was able from time to time to visit the old place. The decision probably was less painful than it otherwise would have been from the fact that his boyhood had been spent in England. At any rate, it was a wise one, in regard to both his own reputation and the progress of science in general.

In the summer of 1850, Sir Charles augmented his experience and refreshed old memories by a tour in Germany. During this he saw for the first time the Roth-todt-liegende or Lower Permian conglomerates at Halle and at Eisenach, as well as the great lava streams which had supplied them with so much of their materials. Also he went to the Brocken in order to examine into Von Buch's extraordinary assertion that the granite had "come up in a bubble." This, it is needless to say, was

* He died November 8th, 1849.

speedily pricked. The loess also, that singular deposit which wraps like a mantle so much of the undulating ground in Northern Germany, evidently engaged his attention, and we find the fruits of these studies in a later work. In addition to all this, he did more than glance at the Maestricht Chalk, the "Wealden" coal of Hanover, the Tertiary deposits near Berlin, the Palæozoic rocks of the Hartz, and the scenery of the Saxon Switzerland.

His books, his scientific papers, and Presidential addresses to the Geological Society, his duties as a commissioner, at first for the Exhibition of 1851, and somewhat later for the reform of the University of Oxford, kept him pretty well employed till August, 1852, when he for the third time crossed the Atlantic to deliver another course of lectures at the Lowell Institute, Boston. Though he was back in England before Christmas, he found time for some geological work in America, the most important item in which was an excursion from Halifax in company with his old acquaintance, Mr. J. W. Dawson, to the Nova Scotian coalfield. On this occasion he passed through a fair amount of country still uncleared, which made the journey more interesting; he had also opportunities of appreciating the effects of ice in moving and piling up boulders on the shores of lakes, and obtained still more evidence in regard to this, on reaching the sea-coast in the neighbourhood of the coalfield. But their labour was rewarded by one discovery of exceptional importance. In the trunk of a tree which had died and become hollow in a forest of the Carboniferous period, they found entombed the skeleton of an animal. Whether this were

a fish or a reptile was at first hotly disputed, but finally it proved to be an amphibian.

On his return to England, Sir Charles was kept for some time fully employed by the preparation of the ninth edition of the "Principles," but early in the summer of 1853 he went for the fourth time to America —on this occasion in company with Lord Ellesmere— as commissioner to the Exhibition held at New York. But now his time was fully taken up by official duties, and his visit was a short one, for he returned before the end of July, and was soon afterwards invited to visit Osborne and give some account of his journey to the Queen and Prince Albert.

Very early in 1854 he again left England, in company with Lady Lyell and Mr. and Mrs. Bunbury, to visit Madeira. Some three weeks were devoted to a careful study of the geology of that island,* partly with the view of determining whether it afforded any support to Von Buch's favourite notion that volcanic cones were mainly formed by upheaval. As might be anticipated, the evidence was distinctly unfavourable. The island was proved to be mainly composed of volcanic material, cones of basaltic scoria, and great flows of similar lava, which had been piled successively one on another in the open air to a depth of about 4,000 feet. This mass had been subsequently pierced by dykes, worn by storm and stream, and in one or two places deeply grooved by rivers. There were, indeed, some underlying beds of marine origin, which, in one part of the island, rose to a height of 1,200 feet above the sea, and thus

* He had the advantage of the company of Mr. C. Hartung, who was an excellent naturalist and well acquainted with the island.

indicated a certain amount of upheaval; but even this was not of the kind which Von Buch's hypothesis required, while the rest of the evidence, including that afforded by some tuffs containing fossil plants, proved that the major part of the island had been formed above water.

From Madeira they went on to Teneriffe, Palma, and the Grand Canary. Of this part of the journey few details are given, but the results were afterwards incorporated with one of his books.* To the Peak of Teneriffe the reference is comparatively brief. Of Palma the account is much fuller, for this island had been regarded by Von Buch, who visited it in 1825, as a type of his "craters of elevation"—an idea which was dispelled by Lyell's investigation. The Grand Canary, like Madeira, proved to be formed of masses of subaërial volcanic rock, perhaps even thicker than those in Madeira, which also rested upon some upraised marine deposits of Miocene age.

In the course of 1854 Sir Charles received from his own University the honorary degree of D.C.L. Much time was spent in working up the results of his last journey, some of which were communicated to the Geological Society.† In the spring of 1855 he went to the Continent, studying, among other matters, the drifts in the neighbourhood of Berlin. In the summer he visited Scotland, made the acquaintance of Hugh Miller, worked over Arthur's Seat, Blackford Hill, and "the coast of Fife from Kinghorn to Kirkcaldy." It would be hard to find a set of sections

* "Elements of Geology" (sixth edition), pp. 621-635.

† "On the Geology of Some Parts of Madeira" (Quart. Jour. Geol. Soc., x. p. 325).

better adapted for the study of ancient volcanic rocks, both contemporaneous and intrusive, than this coast affords; and his experience in Madeira and the Canaries enabled him to regard "the Edinburgh and Fife rocks with very different eyes."

One or two of his published letters about this period have a special interest, for they show that his views on the origin of species were undergoing a gradual modification. Speaking of some strange variations in the flower of an orchideous plant,* he refers, half in jest, to "ugly facts, as Hooker, clinging (like me) to the orthodox faith, calls these and other abnormal vagaries"; and again, the following sentences do not come from a man who is firm in his belief†:—

"When Huxley, Hooker, and Wollaston were at Darwin's last week, they (all four of them) ran a tilt against species further, I believe, than they are deliberately prepared to go—Wollaston least unorthodox. I cannot easily see how they can go so far, and not embrace the whole Lamarckian doctrine. Huxley held forth last week about the oxlip, which he says is unknown on the Continent. If we had met with it in Madeira and nowhere else, or the cowslip, should we not have voted them true species? Darwin finds, among his fifteen varieties of the common pigeon, three good genera and about fifteen good species, according to the received mode of species and genus-making of the best ornithologists, and the bony skeleton varying with the rest! After all, did we not come from an ourang, seeing that man is of the Old World, and not from the American type of anthropomorphous mammalia?"

* In a letter to Mr. Bunbury, dated November 13th, 1854 (Life, Letters, and Journals, vol. ii. p. 199). It is written from 53, Harley Street, one in the previous August bearing the superscription of 11, Harley Street, so that he appears (though there is no allusion to this in his published letters or journals) to have removed into another house in the same street. The number of this was subsequently altered.

† Another letter to Mr. Bunbury, dated April 30th, 1856 (*ibid.*, p. 212).

Sir Charles and Lady Lyell were again on the Continent in the summer of 1856, examining the drifts of Northern Germany, visiting Humboldt at Berlin, discussing geological questions, especially in regard to Carboniferous plants, at Breslau with Roemer and Goeppert; working over the Riesengebirge; then going on to Dresden, and passing through the Saxon Switzerland to Aussig. The coal-field north-west of the former city was not neglected, the great breccia beds of the Rothliegende were again examined, and account was taken of Ramsay's opinion that certain British Permian breccias were glacial in origin. Close attention was also bestowed upon the great masses of hard quartzose grit, through which the Elbe has carved its way—the Quader of Saxony; for this formation, "a grit wholly deficient in calcareous matter, corresponds to the more purely calcareous rock (Chalk) of Great Britain, and yet contains here and there the same shells." He did not neglect the Brown Coal* between Töplitz and Aussig, and, on reaching Prague, made the acquaintance of Barrande, who took him to see those older Palæozoic rocks among which the great palæontologist had been labouring for nearly a quarter of a century. Then the travellers proceeded to Vienna, and after that to the Styrian Alps, to visit various interesting sections in the Salzkammergut, such as the classic ground at Gosau and the Triassic limestones near Hallstadt, where the last survivors of the Palæozoic ages are entombed with the representatives of the period. His letters, like many others of earlier date, indicate that, notwithstanding the fascinations of geology,

* This deposit belongs to the Tertiary era (Oligocene system).

neither living molluscs, nor insects, nor plants had ceased to interest. They returned by way of Munich, Ulm, Zürich and Paris, reaching England about the end of October.

The summer of 1857 was devoted to another Continental tour, rather more restricted than the former, but by no means unimportant. They went leisurely through Belgium and up the Rhine into Switzerland, halting at different places either to study sections of special interest or to confer with eminent geologists. Part of a letter written at this time * gives a valuable insight into the intention of these journeys and the character of the author, who was now in his sixtieth year:—

"I hope to continue for years travelling, making original observations, and, above all, going to school to the younger, but not, for all that, young geologists, whom I meet everywhere, so far ahead of us old stagers that they are familiar with branches of the science, fast rising into importance, which were not thought of when I first began."

Switzerland, obviously, was visited on this occasion with a very definite purpose. De Charpentier, Escher von der Linth, and other local geologists, had been for some time asserting that the glaciers of the Alps, at no remote epoch in geological history, had attained to an enormous size, had buried the Swiss lowland and covered it with morainic deposits, and had even welled up high against the flanks of the Jura, where the huge blocks of protogine from the Mont Blanc range—such as Pierre à bot and its companion erratics, full 800 feet above the Lake of Neuchâtel—indicated one position of its terminal moraine. For-

* Life, Letters, and Journals, ii. p. 243.

merly, in common with many other geologists, Sir Charles had supposed these blocks to have been transported from the Alpine peaks by ice-rafts on the sea, at a time when the whole region stood at a considerably lower level. But now, after examining the erratics, their regular and significant distribution, the other glacial débris, the ice-worn surfaces of rock beneath it, and ascertaining the distinctly terrestrial character of the deposits all about the mountains, he unreservedly admitted land-ice to be the only possible agent, and, in accepting this hypothesis, perceived clearly that he must not shrink from applying it to Scotland. Then he plunged into the mountains to examine and follow the track of the retreating ice-sheet up to the glaciers which are still at work among the higher peaks, passing up the valley of the Reuss, crossing the Furka Pass, and descending the Rhone valley to Visp, but turning aside to examine the earth pillars on the flank of the Eggishorn.* Another, and a larger group of these pillars—instances of the erosive action of rain-water on morainic material—was seen near Stalden, in the Visp-thal; but these had been damaged by the earthquake which two years before had severely shaken this part of the Alps. At Zermatt the characteristics of glaciers and the effects of ice were carefully studied among the grandest of Alpine scenery; then, on returning to the Rhone Valley, they crossed the Alps by the Simplon and went on to Turin. Here he took the opportunity of visiting the huge moraine near Ivrea, which rises from the lowland like a range

* The largest, called the Zwerglithurn, is about one and a half hours walk above Viesch.

of hills, and of investigating the erratics of the Superga, satisfying himself that they really belonged to the Miocene deposits of that hill, and were indicative of the existence of glaciers in the Alps of that epoch, which had been large enough to reach the sea-level, and to send off masses of ice laden with boulders. Then they went on to Genoa, and along the beautiful Riviera di Levante to Pisa; thence, after a short visit to Florence, proceeding direct from Leghorn to Naples. Here, he once more examined Vesuvius, and had the luck to see lava streams actually in motion—"some going fast, others going very slow"—a sight which "gave him many new ideas." A study also of the dykes of Somma convinced him that they afforded no support to De Beaumont's idea of a distension of the mass.*

From Naples he went to Sicily, in order to make a second examination of Etna, and then, after rejoining Lady Lyell, spent some time in the neighbourhood of Rome, visiting the old volcanic district of the Alban Hills, and making excursions, as they travelled northward, into the Apennines. They returned through France, reaching London towards the end of December.

But, for a worker so thorough in his methods, this visit to the volcanoes was not enough, so next year, after spending the earlier part of the summer with his brother's† family in the neighbourhood of Darmstadt, he left Lady Lyell there, and set off

* This had been asserted in support of the hypothesis of "craters of elevation."

† Colonel Lyell had retired from the army and returned to England a short time before the outbreak of the Indian Mutiny.

towards the end of August for a third examination both of Vesuvius and of Etna. Travelling rapidly up the valley of the Rhine, he went by Geneva to Culoz, and over Mont Cenis to Turin and Genoa, without halting for geological work, and thence by sea to Naples. Lava was still flowing from Vesuvius, that black mass, with its strange rope-like folds and slaggy wrinkles,* now so well known to every visitor. Accompanied by Professor Guiscardi—one of the most genial and helpful of leaders—Sir Charles made his way to a vent at the base of the principal cone, where the lava was still welling forth from "a small grotto, looking as fluid as water where it first issued, and moving at a pace which you would call rapid in a river. White-hot, at first, in a canal four or five feet broad, then red before it had got on a yard, then in a few feet beginning to be covered by a dark scum, which thickened fast and was carried along on the surface." But the great question, whether a volcano was mainly a "crater of elevation" or a "crater of ejection," was ever present to his mind; so, in addition to studying the grand sections displayed in the crags of Monte Somma, he devoted two days to the exploration of the ravines which furrow its outer slopes. He also found time to have another look at the Temple of Serapis, and to examine the Solfatara, which is a striking example of a crater at once broad and low.

After a week's halt at Naples, Sir Charles resumed his journey to Sicily, landing at Messina on September 10th. By the 15th he was once more on the slopes of

* *See* Professor J. W. Judd: "Volcanoes" (International Scientific Series), Fig. 22.

Etna, and had begun a twelve-day period of hard work on the mountain, passing five nights in very rough quarters at the Casa degli Inglesi, 9,600 feet above sea-level. During this stay he ascended the principal cone, carefully examining both the larger and the smaller craters, and descended into the Val del Bove, a laborious expedition, but one which well repaid him by throwing much light on the structure of the volcanic mass. Still he was not yet satisfied, for after he had descended to Zafarana, he returned to spend another night at the Casa degli Inglesi in order to satisfy himself about one or two details. From Zafarana also he went again to the Val del Bove, checking and increasing his notes, and devoted another day to a most interesting excursion through picturesque scenery as far as the watershed between this vast hollow in the mountain side and the neighbouring Val di Tripodo. On all these excursions Sir Charles, as far as possible, rode, remarking to his wife, "I feel here that a good mule is like presenting an old geologist with a young pair of legs." Work on the mountain ended, he spent a little time in examining the Tertiary beds of the neighbouring lowland, and then, getting back to Messina about the middle of October, returned in due course to England.

These two journeys in succession greatly augmented his knowledge of the structure of volcanic cones, and enabled him to deal the death-blow to the "crater of elevation" hypothesis which had found such favour among Continental geologists. He could now prove that lava would solidify in a compact form on slopes of thirty-five or even forty degrees—a fact which had been stoutly denied by advocates of that

hypothesis, and was able to offer an explanation of the singular structure of the Val del Bove, viz. that it was a huge gulf, formed by a series of mighty explosions, similar to those which shattered half of the old crater of Vesuvius,* and sent one side of Bandai San† flying through the air. He returned to England satisfied that his feet were on firm ground, if such a phrase be permissible in regard to a volcano, and that the results‡ of this conscientious labour in the fulness of his age had strengthened him in the position which he had adopted in his scientific youth.

In the next year (1859) Lyell also travelled, though the journeys were not so lengthy as their two predecessors. Still, in the spring he visited both Holland and Le Puy in Auvergne, and in the earlier part of the autumn attended the meeting of the British Association at Aberdeen, under the presidency of Prince Albert. A strong body of geologists were present, and Lyell was for the fourth time in the chair of the Geological Section, the Prince coming to hear his address. Among the old friends whom he met was one who would have been a suitable husband for the famous Countess of Desmond, for Lyell writes of him to Mrs. Horner, his wife's mother, "Dr. F. at ninety-four looks well enough, but having eaten turtle-soup, and melon too close to the rind, and other imprudences, is not quite well to-day!" *O dura Doctorum ilia!* The meeting ended, Lyell with some geological friends

* In the famous eruption of A.D. 79.

† A volcano of Japan.

‡ These results are worked into the tenth edition of the "Principles" (chaps. xxv. and xxvi.). *See also* a paper on Stony Lava on Steep Slopes of Etna (Proc. Roy. Soc. 1858, ix. p. 248). He received the Copley Medal from the Royal Society in November.

went off to Elgin to examine the sandstone quarried at Cutties Hillock, near that town. The rock closely resembles the ordinary Old Red Sandstone; it seemed at first sight to form a continuous mass, yet in one place it contained a fossil fish belonging to that period, and in another the remains of a reptile (*Telerpeton*). After some days of careful study, the Rev. W. S. Symonds, who was one of the party, came to the conclusion (which has been fully ratified by later investigations) that the deposits were of different ages; the one with the fish being truly "Old Red," the other, with the reptile, "New Red." The chief cause of the puzzle is that the sand which has been derived from the older rock has gone to form the newer one, and that the usual indications of a discontinuity are practically absent. It affords a valuable caution, for it shows that Nature sometimes does set traps, which might well catch even the most wary geologist.

In the same autumn Lyell read Darwin's great work on "The Origin of Species," by which his scientific position was finally determined, for his letters show that, if any objection to the leading principles in his friend's views had still lingered in his mind, they were overcome by the perusal of this masterly specimen "of close reasoning and long sustained argument."

CHAPTER X.

THE ANTIQUITY OF MAN.

THOUGH many men on reaching their sixty-third year are content to rest upon their oars and not to attempt new ventures, Lyell had plunged into a question which was arousing almost as much excitement as the origin of species—namely, the antiquity of man. It was a question, indeed, which for a long time must have been before his mind—witness his remarks on Dr. Schmerling's work in the caves near Liége; but it had assumed a special significance owing to the famous discovery of flint implements in the valley of the Somme.* The whole subject also would have a special interest for Lyell, because he had made Tertiary deposits his special field in stratigraphy, and had worked at this subject downwards, comparing extinct with living forms, so that he had seen more than others of the borderland which blends by an insensible transition the province of the geologist with that of the archæologist. Probably also the thought which he had been giving to the question of the origin of species would bring into no less vivid prominence that of the age and origin of the human race. Be this as it may, he undertook a task comparatively novel, and for the next three years was fully occupied

* Found by M. Boucher de Perthes, who had published a book on the subject in 1847, and had announced the discovery about seven years earlier; but geologists, for various reasons, were not fully satisfied on the matter till the visit of Messrs. Prestwich and John Evans (now Sir) in 1857.

in the preparation of his third great book, "The Antiquity of Man." Travel was necessary for this purpose also; but as the journeys were less lengthy than those already described, and led him for the most part over old ground, it is needless to enter into details. He visited the gravels of the Somme Valley and the caves on the Meuse, besides other parts of Northern France and Belgium,* the gravel pits near Bedford, and various localities in England, examining into the evidence for himself, and paying particular attention, not only to the question of man's antiquity, but also to the supposed return of a warmer climate than now prevails after the era of glacial cold. The book was published early in 1863. Naturally its conclusions were startling to many and were vigourously denounced by some; but it was a great success, for it ran through three editions in the course of the year. A fourth and enlarged edition was published in 1873.

The book may seem, from the literary critic's point of view, rather composite in character, and this objection was made in a good-natured form by a writer in the *Saturday Review*,† who called it "a trilogy on the antiquity of man, ice, and Darwin." That, however, is but a slight blemish, if blemish it be, and it was readily pardoned, because of the general interest of the book, the clearness of its style, and the lucidity of its reasoning.

In accordance with his usual plan of work—proceeding tentatively from the known to the unknown

* He went to Florence in 1862, but how far this was for geological work is not stated.

† Vol. xv. p. 311.

—Lyell begins with times nearest to the present era and facts of which the interpretation is least open to dispute. He conducts his reader at the outset to the peat mosses of Denmark, where weapons of iron, bronze, and stone lie in a kind of stratified order; and to those mounds of shells, the refuse heaps of a rude people, which are found on the Baltic shore. Next he places him on the site of the pile-built villages which once fringed the shores of Swiss and Italian lakes. Here weapons of iron, of bronze, and of stone are hidden in peat or scattered on the lake-bed. But these log-built settlements, such as those which Herodotus described at Lake Prasias in Roumelia, are not the only remnants of an almost prehistoric people, for nearer home we find analogous constructions in the crannoges of Ireland—islets partly artificial, built of timber and stone. Lyell then passes on from Europe to the valleys of the Nile and Mississippi, and so to the "carses" of Scotland. In the last case canoes buried in the alluvial deposits, as in the lowland by the Clyde, indicate that some physical changes, slight though they may be, have occurred since the coming of man. But none of these researches lead us back into a very remote past; they keep us still lingering, as it were, on the threshold of history. The weapons which have been described, even if made of stone, exhibit a considerable amount of mechanical skill, for many of them are fashioned and polished with much care, while they are associated with the remains of creatures which are still living at no great distance, if not in the immediate vicinity. Accordingly he conducts his reader, in the next place, to the localities where ruder weapons only have been found, fashioned

by chipping, and never polished—namely, to the caves of Belgium and of Britain, of Central and of Southern France, and to the gravel beds in the valleys of the Somme and the Seine, of the Ouse and other rivers of Eastern and Southern England. These furnish abundant evidence that man was contemporary with several extinct animals, such as the mammoth and the woolly rhinoceros, or with others which now inhabit only arctic regions, such as the reindeer and the musksheep, and that the valleys since then have been deepened and altered in contour. This evidence, stratigraphical as well as palæontological, proves that important changes have occurred since man first appeared, not only in climate, but also in physical geography.

The Glacial Epoch is the subject of the second part of the book. Its pages contain an admirable sketch of the deposits assigned to that age in Eastern England, Scandinavia, the Alps, and North America, with special descriptions of the loess of Northern Europe, the drifts of the Danish island of Möen, so like those near Cromer, and the parallel roads of Glenroy, which Lyell now supposes to have been formed in a manner similar to that of the little terrace by the Märjalen See.

The third part deals with "the origin of species as bearing on man's place in Nature." It is a recantation of the views which he had formerly maintained. In all his earlier writings, including the ninth edition of the "Principles," he had expressed himself dissatisfied with the hypothesis of the transmutation of species, and had accepted, though cautiously and not without allowing for considerable power of variation,

that of specific centres of creation. Now, after a full review of the question, he gives his reasons for abandoning his earlier opinions and adopting in the main those advocated by Darwin and Wallace. Nevertheless, through frankly avowing his change of view, he advances cautiously and tentatively, like a man over treacherous ice—so cautiously, indeed, that Darwin is not wholly satisfied with his convert, and chides him good-humouredly for his slow progress and overmuch hesitation. But this very hesitation was as real as the conversion: the one was the outcome of Lyell's thoroughly judicial habit of mind, the other was a proof, perhaps the strongest that could be given, of that mind's freshness, vigour, and candour. The book ends with a chapter on "man's place in Nature." On this burning question the author speaks with great caution, but comes to the conclusion that man, so far as his bodily frame is concerned, cannot claim exception from the law which governs the rest of the animal kingdom; and he ends* with a few words on the theological aspect of the question: "It may be said that, so far from having a materialistic tendency, the supposed introduction into the earth, at successive geological periods, of life—sensation—instinct—the intelligence of the higher mammalia bordering on reason—and, lastly, the improvable reason of man himself, presents us with a picture of the ever-increasing dominion of mind over matter."

* "Antiquity of Man," chap. xxiv.

CHAPTER XI.

THE EVENING OF LIFE.

THE second and third editions of the "Antiquity of Man" were not mere reprints, since new materials were constantly coming in and researches were continued; for during the summer of 1863 Sir Charles was rambling about Wales, visiting the caves of Gower in Pembrokeshire, and of Cefn in Denbighshire, the peats of Anglesea, and the boulder clay and shell-bearing sands near the top of Moel Tryfaen. He also went over to Paris, apparently about this time, to inquire into the authenticity of specimens—bones with notches upon them—which were supposed to prove man contemporaneous with the Cromer Forest Beds of England, and therefore pre-glacial. Shorter journeys were to Osborne (by Royal command), to Suffolk, and to Kent.

While engaged on the above-named book, he had persistently refused more than one position of honour —such as a Trusteeship at the British Museum, to be a candidate for the representation of the University of London in Parliament, even an honorary degree from the University of Edinburgh because he was too busy to undertake the journey. In 1861, also, he seems to have received a warning that he was beginning to grow old, for he became rather seriously unwell, and was ordered to Kissingen in Bavaria to take a course of the waters. But during the same period two acceptable honours were received—namely,

the Corresponding Membership of the Institute of France, in 1862, and an order of Scientific Merit from the King of Prussia in the following year.

The years, as must be the case when life's evening shadows are lengthening, begin to be more definitely chequered with losses and with rewards. In his letters, references to the death of friends become frequent. In 1862 Mrs. Horner, Lady Lyell's mother, died, and in 1864 her father, Leonard Horner, with whom, even for some years before becoming his son-in-law, Lyell had been in constant friendly correspondence, passed away in his eightieth year. In the same year Lyell was raised to the rank of baronet, and also occupied the presidential chair at the meeting of the British Association at Bath.

His address deals principally with two topics—one local, thermal springs, especially those of Bath; the other general, the glacial epoch and its relation to the antiquity of man. He refers, however, in the concluding paragraph to the marked change which, within his memory, opinion had undergone, in regard to catastrophic changes and the origin of species, and to the discovery of the supposed fossil *Eozoon Canadense* in the crystalline Laurentian rocks of Canada. This singular structure appeared to him—as it did to Sir W. Logan, who had brought specimens for exhibition at the meeting—to be a fossil organism,* and thus to indicate the existence of living creatures at a much

* The nature of *Eozoon*, whether it be the remains of a foraminifer of unusual size and peculiar habit of growth, or merely a very exceptional arrangement of its constituent minerals, has been since the above-named date a fruitful subject of controversy. For some years the balance of opinion was in favour of an organic origin; now it seems to be distinctly tending in the other direction.

earlier period than hitherto had been supposed. But in stating this opinion he checks himself characteristically with these words: "I will not venture on speculations respecting 'the signs of a beginning,' or 'the prospects of an end' of our terrestrial system—that wide ocean of scientific conjecture on which so many theorists before my time have suffered shipwreck."

The address contains more than one passage that is well worth quotation, but the following has so wide a bearing, and is so significant as to the effects of early influences, that it should not be forgotten:—

"When speculations on the long series of events which occurred in the Glacial and post-Glacial periods are indulged in, the imagination is apt to take alarm at the immensity of the time required to interpret the monuments of these ages, all referable to the era of existing species. In order to abridge the number of centuries which would otherwise be indispensable, a disposition is shown by many to magnify the rate of change in prehistoric times, by investing the causes which have modified the animate and inanimate world with extraordinary and excessive energy. It is related of a great Irish orator of our day, that when he was about to contribute somewhat parsimoniously towards a public charity, he was persuaded by a friend to make a more liberal donation. In doing so, he apologised for his first apparent want of generosity by saying that his early life had been a constant struggle with scanty means, and that 'they who are born to affluence cannot easily imagine how long a time it takes to get the chill of poverty out of one's bones.' In like manner, we of the living generation, when called upon to make grants of thousands of centuries in order to explain the events of what is called the modern period, shrink naturally at first from making what seems to be so lavish an expenditure of past time. Throughout our early education we have been accustomed to such strict economy in all that relates to the chronology of the earth and its inhabitants in remote ages, so fettered have we been by

old traditional beliefs, that even when our reason is convinced and we are persuaded that we ought to make more liberal grants of time to the geologist, we feel how hard it is to get the chill of poverty out of our bones." *

A presidential address to the British Association is no light task; but, in addition to this, Lyell was now engaged upon a new edition of the "Elements (or Manual) of Geology," which for some time had been urgently demanded; the last edition also of the "Principles"—though 5,000 copies had been printed—was practically exhausted. The former work was cleared off before the end of the year, the book appearing in January, 1865, and the latter was at once taken vigorously in hand, as we see from a letter questioning Sir John Herschel about the earth-pillars on the Rittnerhorn, near Botzen, and on the influence which changes in the shape of the earth's orbit and the position of its axis would have upon climate—a view which had been advocated by Dr. Croll. Lyell, it will be remembered, had originally regarded geographical conditions as the only factors which modified climate, but he was evidently impressed by Croll's argument, and ready, if his mathematics were correct, to admit astronomical changes as an independent, though probably less potent, cause of variation.

The Christmas of 1864 and the following New Year were spent in Berlin, and in the summer of 1865 he had again recourse to Kissingen. Though he writes that the waters "did him neither harm nor good," he was at any rate well enough after the "cure" to undertake a rather lengthy tour with Lady

* Report of Brit. Assoc., 1864, p. xxiv.

Lyell and his nephew* Leonard, in the course of which he examined for himself the wonderful earth-pillars near Botzen, and visited the Märjalen See, that pretty lake held up by the ice of the great Aletsch Glacier, in order to see whether it threw any light on the origin of the parallel roads of Glenroy. He was satisfied that it did, for he found there a large terrace "exactly on a level with the col which separates the valley" occupied by the lake from that of the Viesch glacier. On his return to England, he writes a long letter to Sir John Herschel, discussing the origin of these earth-pillars, and making inquiries as to the precise points from which his friend, more than forty years before, had made some elaborate drawings. The expedition, as well as the letter, to quote Lyell's own words, were pretty well for a man who was "battling with sixty-eight years." He complains, however, of little more than occasional attacks of lumbago, and a necessity for taking great care of himself; but his eyes were now more troublesome than they had been, and for the last year he had been driven to avail himself of the services of a secretary,† with the result that he seemed to have acquired a new lease of his eyes, and to be able, for ordinary purposes, to use them almost as well as formerly.

After his return from the Continent Sir Charles was working hard at the new edition of the "Principles," which obviously gave him much trouble, for letters still remain which were written to Herschel on questions relating to climate and astronomy; to

* Colonel Lyell's eldest son, the present baronet.

† He was fortunate in obtaining the help of Miss Arabella Buckley a lady of congenial tastes in literature and science.

Hooker, Wallace, and Darwin on the transmutation of species, the distribution and migration of plants and animals, the effects of geographical changes, and even on such matters as the Triassic reptilia of Elgin and Warwickshire, Central India and the Cape. At last the first volume of the new and much-enlarged edition (tenth) was published in November, 1866, the second volume not appearing till 1868. Few men at that time of life could have accomplished such a piece of work, especially if they had been compelled, as Lyell was, to read with the eyes and write with the hands of others. But even now, in regard to field work, he was still able to see things for himself, and, though less vigorous than formerly, to undertake journeys of moderate length. In 1866, in company with his nephew Leonard, he examined the Glacial and late Tertiary deposits of the Suffolk coasts; looked once more at the sections of Jurassic rocks in the Isle of Portland and the neighbourhood of Weymouth, and doubtless speculated on the origin of the Chesil Bank and of the Fleet. One honour fell to him in this year, which, doubtless, only the accident of his long service on the Council had previously kept from him —namely, the Wollaston Medal of the Geological Society.

In 1867 he was strong enough to visit the Paris Exhibition, after which he went to Forfarshire, and attended the meeting of the British Association at Dundee. In the following year he was present at the same gathering in Norwich, besides making various shorter journeys in England and spending September in Pembrokeshire with Lady Lyell and

his brother's family,* in whose company evidently he took much pleasure.

In the spring of 1868 he was again in the field, examining the splendid plant remains of Eocene age in the neighbourhood of Bournemouth and Poole, and the shallow-water deposits of the Purbeck group ripple-marked and sun-cracked, together with the traces of their ancient forests. Over these he became as enthusiastic as any young geologist. At this time also, apparently, he visited the Blackmore Museum † at Salisbury, and himself found reindeer antlers in the neighbouring gravels at Fisherton. In the autumn they again stayed at Tenby with Colonel Lyell's family, when one of the latter was attacked by a serious illness. But Sir Charles was able to take his nephew Leonard to St. David's, and examine the magnificent sections of fossiliferous Cambrian rocks, under the guidance of Dr. H. Hicks, whose name is inseparably connected with the geology of this district.

Comparatively few records are preserved of the last six years of his life; still they are enough to show that his interest in science never flagged. The few letters which have been printed show no signs of declining mental strength. Though his bodily powers had become less vigorous, though his sight was weak, and his limbs were less firm than in the olden times, he was by no means ready to be laid altogether on the shelf. For instance, in the spring of 1869 he went back to the coast of Suffolk and Norfolk, to

* The relationship was unusually close, for Colonel Lyell had married another Miss Horner.

† For a description of this fine collection of prehistoric antiquities, *see* "Flint Chips," by E. T. Stevens, 1870.

resume work which he had been unable to complete on his last visit.

Starting at Aldborough, where Pliocene deposits are still exposed, from the Coralline Crag up to the Chillesford group, they examined the coasts by Southwold and Kessingland to Lowestoft, seeing "a continuous section, for miles unbroken, of the deposits from the upper part of the Pliocene to the glacial drift." The Kessingland cliffs afforded good sections of the "Forest Bed," the deposit which on former occasions he had studied in the neighbourhood of Cromer. It was covered by several yards of stratified sand, and that by glacial drift, "with the usual 'boulders' of chalk, flint, lias, sandstone, and other sedimentaries, with crystalline rocks from more distant places." Passing on into Norfolk, they followed this "Forest Bed" and the overlying boulder clay, and they found in the latter, near Happisburgh, some fragments of sea-shells, and one perfect valve of *Tellina solidula* in a band of gravel, "like a fragment of an old sea-beach," intercalated in the glacial clay. As the origin of this clay has been, of late years, a subject of dispute, it may be interesting to quote Sir Charles's conclusion:—"I suppose, therefore, we must set it down as a marine formation; and underneath it, from Happisburgh to Cromer, comes the famous lignite bed and submarine forest, which must have sunk down to allow of the unquestionable glacial formation being everywhere superimposed." *

On revisiting Sherringham (a village about five miles along the coast to the west of Cromer), he found a striking instance of that "sea change" to which

* Life, Letters, and Journals, ii. p. 440.

in his early days he had called attention. "Leonard and I" (he writes to Sir C. Bunbury) "have just returned from Sherringham, where I found that the splendid old Hythe pinnacle of chalk, in which the flints were vertical, between seventy and eighty feet high, the grandest erratic in the world, of which I gave a figure in the first edition of my "Principles," has totally disappeared. The sea has advanced on the lofty cliff so much in the last ten years, that it may well have carried away the whole pinnacle in the thirty years which have elapsed since our first visit."

Another letter, bearing date in the next month, to Darwin shows that in his seventy-second year his mind was fresh and keen as ever. It discusses an article written by Wallace in the *Quarterly Review*, and indicates the difference in regard to natural selection between Lyell's own standpoint and that of his correspondent. The following extract may serve to show the general tenor of the remarks:—"As I feel that progressive development in evolution cannot be entirely explained by natural selection, I rather hail Wallace's suggestion that there may be a Supreme Will and Power, which may not abdicate its functions of interference, but may guide the forces and laws of Nature." In another passage he refers to a controversy which had been recently started by Professor (afterwards Sir A.) Ramsay, and over which geologists have been fighting ever since —viz. whether lake-basins are excavated by glaciers. The passage is worth quoting, for it puts the issue in a form which after a quarter of a century is virtually unchanged:—

"As to the scooping out of lake-basins by glaciers, I have had a long, amicable, but controversial correspondence with Wallace on that subject, and I cannot get over (as, indeed, I have admitted in print) an intimate connection between the number of lakes of modern date and the glaciation of the regions containing them. But as we do not know how ice can scoop out Lago Maggiore to a depth of 2,600 feet, of which all but 600 is below the level of the sea, getting rid of the rock supposed to be worn away as if it was salt that had melted, I feel that it is a dangerous causation to admit in explanation of every cavity which we have to account for, including Lake Superior. They who use it seem to have it always at hand, like the 'diluvial wave or the wave of translation,' or the 'convulsion of nature or catastrophe' of the old paroxysmists."*

In the summer he took a longer tour, going first to Westmoreland and then to Forfarshire; after which, in company with Lady Lyell and his nephew, he went to see the old rocks of Ross-shire, above Inchnadamff and Ullapool, and, as he returned, once more visited the parallel roads of Glenroy.

But, in the meantime, notwithstanding the difficulties mentioned above, he still kept working at his books. He was now engaged in modifying the "Elements of Geology." Of this, to quote the preface afterwards published, he had published "six editions between the years 1838 and 1865, beginning with a small duodecimo volume, which increased with each successive edition, as new facts accumulated, until in 1865 it had become a "large and somewhat expensive work." He therefore determined, in accordance with the advice of friends, "to bring the book back again to a size more nearly approaching the original, so that it might be within the reach of the ordinary student." This was done

* Life, Letters, and Journals, ii. p. 443.

by the omission of certain theoretical discussions and all such references to Continental geology as were not absolutely necessary.*

In 1870 Sir Charles continued to travel, though within the limits of these islands, for he made one journey along the coast of North Devon, and a second one to Scotland, in the course of which he visited the Isle of Arran, and on his return halted first at Ambleside and then at Liverpool, to attend the meeting of the British Association, which began on the 14th of September. The following year he paid an April visit to Tintagel, the Land's End, and other parts of Cornwall, and in the summer went to the North of England. Writing from Penrith to Sir C. Bunbury, he remarks "that he had much enjoyed his 'tour of inspection,' and had tried to make it a tour of rest, which is difficult." Naturally so, for he had been working his way from Buxton on the look-out for glacial deposits and studying especially the stratified drifts on the hills east of Macclesfield, 1,200 feet above the sea. His remarks on these show that he appreciated fully both the significance of the marine fossils which they contain and the theoretical difficulties caused by the absence of such remains in other deposits, whether in Derbyshire or the Lake District, or in the lowland between this locality and Moel Tryfaen, seventy-four miles away.

The tenth edition of the "Principles" had been

* The book, thus abbreviated, and entitled "The Student's Elements of Geology," was published in 1871. A second edition appeared in February, 1874; a third, revised by Mr. Leonard Lyell and others, in 1878; and a fourth, edited by Prof. P. M. Duncan, in 1885.

quickly sold, and Sir Charles was now employed in the preparation of another one. In this less change was necessary than on the last occasion; still, the rapid increase of knowledge, more especially in regard to the temperature and currents of the sea, obliged him to make considerable alterations in the parts which dealt with these subjects and with questions of climate, so that he recast or rewrote five chapters.

It was published in January, 1872; and in the summer of that year, no doubt in view of a new edition of the "Antiquity of Man," he went to the south of France, with Lady Lyell and Professor T. M'K. Hughes, to examine the Aurignac cave. Here several human skeletons had been discovered some years before, apparently entombed with the bones of various extinct mammals, such as the cave-bear and lion, the mammoth and woolly rhinoceros—in short, with a fauna characteristic of the palæolithic age. But was this really the date of the interment? Some distinguished geologists were of opinion that, though the cave had been then occupied by wild beasts, its floor had been disturbed, and the corpses buried in neolithic times. On this point Lyell was unable to obtain conclusive evidence, and was obliged to confine himself to a statement of the facts and arguments on either side of the question.*

Shortly after the publication of this new edition of the "Antiquity of Man" in January, 1873, an unexpected and irreparable bereavement darkened the evening of his days. On April 24th Lady Lyell, the companion and helpmate of forty years, was taken

* "Antiquity of Man" (fourth edition), chap. vii.

from him after a few days' illness from an inflammatory cold.* The shock was the more severe because the loss was so unforeseen. Lady Lyell was twelve years his junior, and had always enjoyed good health †—"youthful and vigorous for her age," as he writes—so that he "never contemplated surviving her, and could hardly believe it when the calamity happened." He bore the blow bravely, consoling himself by reflecting that the separation, at his age—nearly seventy-six—could not be for very long, and, as he writes to Professor Heer, of Zürich, endeavouring, "by daily work at my favourite science, to forget as far as possible the dreadful change which this has made in my existence."

Lady Lyell was a woman of rare excellence. "Strength and sweetness were hers, both in no common degree. The daughter of Leonard Horner, and the niece of Francis Horner, her own excellent understanding had been carefully trained, and she had that general knowledge and those intellectual tastes which we expect to find in an educated Englishwoman; and from her childhood she had breathed the refining air of taste, knowledge, and goodness. Her marriage . . . gave a scientific turn to her thoughts and studies, and she became to her husband, not merely the truest of friends and the most

* She had been suffering from influenza, but had accompanied her husband and nephews to Ludlow at the beginning of the month. They became uneasy at her increasing debility, and returned to town on the 14th ("Life, Letters, and Journal of Sir C. Bunbury," iii. p. 9).

† He mentions, on January 5th, 1856, that she had not been well enough to breakfast with him, "for the second time only since our marriage."

affectionate and sympathetic of companions, but a very efficient helper. She was frank, generous, and true; her moral instincts were high and pure; she was faithful and firm in friendship; she was fearless in the expression of opinion without being aggressive; and she had that force of character and quiet energy of temperament that gave her the power to do all that she had resolved to do. . . . She had more than a common share of personal beauty; but had she not been beautiful she would have been lovely, such was the charm of her manners, which were the natural expression of warmth and tenderness of heart, of quick sympathies, and of a tact as delicate as a blind man's touch." *

He was not, however, left to bear in solitude the burden of darkening sight and of a desolated home. His eldest sister, Miss Lyell, came from Kinnordy to take care of his house and watch over him in these last years with an affectionate devotion; and in her company and that of Professor Hughes he even carried out the plan, which had been already in contemplation, of once more going on to the Continent and of visiting Professor Heer, at Zürich.

He worked on, as well as slowly increasing infirmities allowed, after his return to England, fully occupied in preparing a second edition of the "Student's Elements" and a new one of the "Principles." † In June, 1874, he again visited Cambridge, this time to receive the degree of LL.D. — an

* Quoted from an obituary notice by G. S. Hillard, Esq., in the *Boston (U.S.) Daily Advertiser* (printed in Life, Letters, and Journals, ii. p. 467).

† This was published after his death. He had completed one volume; the other was revised by his nephew Leonard.

honour which that University had been strangely slow in conferring upon him.* It was then too evident that his strength was declining, for he became quickly fatigued by any exertion of body or mind; nevertheless, he was able soon afterwards to make once more the journey to Forfarshire, and to visit there several of his earlier geological haunts. In some of these little excursions he had as his companion Mr. J. W. Judd,† with whose recent researches into the ruined volcanoes of Tertiary age and the yet earlier stratified rocks in the Western Isles of Scotland Sir Charles was hardly less interested than he would have been in the days when the "Principles" was a new book. Three or four letters written about this time have been printed ‡ which show, from their vigour and freshness, that the mind was still keen and bright, though the bodily machinery was becoming outworn. After his return to town he even ventured, on November 5th, to dine at the Geological Club,§ of which he had been a member from its foundation, on its fiftieth anniversary meeting, and "spoke with a vigour which surprised his friends."

The tale, however, is nearly told; the sands of life were running low. "His failing eyesight and other infirmities now began to increase rapidly, and towards the close of the year he became very feeble.

* About the same time he was admitted to the freedom of the Turners' Company in the City of London.

† Now Professor Judd, F.R.S., of the Royal College of Science, South Kensington.

‡ Life, Letters, and Journals, ii. pp. 453-459.

§ The Club consists of a certain number of Fellows of the Geological Society, who dine together before the evening meetings.

But his spirit was ever alive to his old beloved science, and his affectionate interest and thought for those about him never failed. He dined downstairs on Christmas Day with his brother's family, but shortly after that kept to his room."

On February 22nd, 1875, Charles Lyell entered into his rest. The end may have been slightly accelerated by two causes—one, the death, from inflammation of the lungs, after a short illness, of his brother,* Colonel Lyell, who, up to that time, had visited him almost daily; the other, the shock given to his enfeebled system by accidentally falling on the stairs a few weeks before. But in no case could it have been long delayed; the bodily frame was outworn; the hour of rest had come.

His fellow-workers in science felt unanimously that but one place of sepulture was worthy to receive the body of Charles Lyell—the Abbey of Westminster, our national Valhalla. A memorial, bearing many important signatures, was at once presented to Dean Stanley, who gave a willing consent, and the interment took place with all due solemnity on Saturday the 27th. The grave was dug in the north aisle of the nave, near that of Woodward, one of the pioneers of British geology and the founder of the chair of that science in the University of Cambridge. It is marked† by a slab of Derbyshire marble, which bears this inscription :—

* His brother Thomas, who had retired from the Navy with the rank of captain, had died (unmarried) some years before at the jointure house (Shiel Hill), Kinnordy, where he had resided with one of his sisters.

† A marble bust, a copy by Theed of the original executed by Gibson, is placed near the grave.

CHARLES LYELL,
BARONET, F.R.S.,
AUTHOR OF
"THE PRINCIPLES OF GEOLOGY."
BORN AT KINNORDY, IN FORFARSHIRE,
NOVEMBER 14, 1797;
DIED IN LONDON,
FEBRUARY 22, 1875.

THROUGHOUT A LONG AND LABORIOUS LIFE
HE SOUGHT THE MEANS OF DECIPHERING
THE FRAGMENTARY RECORDS
OF THE EARTH'S HISTORY
IN THE PATIENT INVESTIGATION
OF THE PRESENT ORDER OF NATURE,
ENLARGING THE BOUNDARIES OF KNOWLEDGE
AND LEAVING ON SCIENTIFIC THOUGHT
AN ENDURING INFLUENCE.

"O LORD, HOW GREAT ARE THY WORKS,
AND THY THOUGHTS ARE VERY DEEP."
PSALM XCII. 5.

Sir Charles, by his will, left to the Geological Society of London the die, executed by Mr. Leonard Wyon, of a medal to be cast in bronze, and awarded annually to some geologist of distinction, whether British or foreign. He further left a sum of two thousand pounds, free of legacy duty, to the Society, in trust, the interest of it to be applied as follows:—Not less than one-third of it to accompany the medal, and the remainder to be given, in one or more portions, for the furtherance of the science. Sir Charles was succeeded in the family estates by his nephew Leonard, the eldest son of Colonel Lyell, who lives at Kinnordy, but has rebuilt the house. He was created a baronet in 1894.

CHAPTER XII.

SUMMARY.

In stature, Sir Charles Lyell * was rather above the middle height, somewhat squarely built, though not at all stout, with clear-cut, intellectual features, and a forehead, broad, high, and massive. He would have been a man of commanding presence, if his extremely short sight had not obliged him to stoop and peer into anything he wished to observe. This defect, in addition to the weakness of his eyes was a serious impediment in field work. As Professor Ramsay remarked in 1851, after spending a few days with him in the south of England, he required people to point things out to him, and would have been unable to make a geological map, "but understood all when explained, and speculated thereon well."† This defect of sight, according to Sir J. W. Dawson, who had been his companion in more than one excursion in Canada, was at times even a source of danger. The expression of his face was one of thoughtful power and gracious benignity.‡ "In his work, Lyell was very methodical, beginning and ending at fixed hours. Accustomed to make use of the help of others on

* In this paragraph I have ventured to quote largely, and more or less verbatim, from the words of Miss Buckley (Lyell's secretary) in the article on his life, written by my friend Professor G. A. J. Cole, in the "Dictionary of National Biography," vol. xxxiv.

† "Life of Sir A. Ramsay," by Sir A. Geikie, chap. v.

‡ *Vidi tantum*, when his powers were beginning to fail, but it is this expression which is stamped on my mind as characteristic of the face in Charles Lyell, and, I may add, also in Charles Darwin.

account of his weak sight, he was singularly unconscious of outward bodily movement, though highly sensitive to pain. When dictating, he was often restless, moving from his chair to his sofa, pacing the room, or sometimes flinging himself full length on two chairs, tracing patterns on the floor, as some thoughtful or eloquent passage flowed from his lips. But though a rapid writer and dictator, he was sensitively conscientious in the correction of his manuscript, partly from a strong sense of the duty of accuracy, partly from a desire to save his publisher the expense of proof corrections. Hence passages once finished were rarely altered, even after many years, unless new facts arose."

The characteristic with which anyone who spent some time in Charles Lyell's company was most impressed, was his thirst for knowledge, combined with a singular openness, and perfect fairness of mind. He was absolutely free from all petty pride, and from "that common failing of men of science, which causes them to cling with such tenacity to opinions once formed, even in the face of the strongest evidence."* Ramsay wrote of him,† "We all like Lyell much; he is anxious for instruction, and so far from affecting the bigwig, he is not afraid to learn anything from anyone.‡ The notes he takes are amazing." No

* J. W. Dawson, cited in the "Dictionary of National Biography."

† *Ut suprà.*

‡ I may add my own testimony. When the second edition of the "Student's Elements" was passing through the press, I ventured to write to him about one or two petrological details, which I thought might be more precise. Though at that time I had published but few papers, I received more than one kind letter with the request that I would read some of the proof-sheets of the book and suggest alterations.

man could have given a stronger proof of candour and plasticity of mind and of his care for truth alone than Lyell did in dealing with the question of the origin of species. From the first he approached it without prejudice. So long as the facts adduced by Lamarck and others appeared to him insufficient to support their hypotheses, he gave the preference to some modification of the ordinarily accepted view—that a species began in a creative act—but after reading Darwin's classic work,* and discussing the subject in private, not only with its author, but also with Sir J. Hooker and Professor Huxley, he was convinced that Darwin was right in his main contention, though he held back in regard to certain minor points, for which he thought the evidence as yet insufficient. Of his conduct in this matter, Darwin justly wrote: "Considering his age, his former views, and position in society, I think his action has been heroic."† Dean Stanley, in the pulpit of Westminster Abbey, on the Sunday following the funeral, summed up in a few eloquent sentences the great moral lesson of Lyell's life. "From early youth to extreme old age it was to him a solemn religious duty to be incessantly learning, fearlessly correcting his own mistakes, always ready to receive and reproduce from others that which he had not in himself. Science and religion for him not only were not divorced, but were one and indivisible."‡

To ascertain the truth, and to be led by reason not by impulse, that was Lyell's great aim. Sedgwick

* "The Origin of Species," published in 1859.

† "Life and Letters of C. Darwin," ii. p. 326.

‡ Quoted in Life, Letters, and Journals, ii. p. 461.

once* criticised his work in terms which, in one respect, seem to me curiously mistaken: "Lyell . . . is an excellent and thoughtful writer, but not, I think, a great field observer . . . his mind is essentially deductive not inductive." The former criticism, as has been already admitted, is just, but the latter, *pace tanti viri*, seems to me the reverse of the truth. Surely there never was a geologist whose habits and methods were more strictly inductive than Lyell's. He would spare no pains, and hardly any expense, to ascertain for himself what the facts were; he abstained from drawing any conclusion until he had accumulated a good store; he compared and marshalled them, and finally adopted the interpretation with which they seemed most accordant. This interpretation, however, would be modified, or even rejected, if new and important facts were discovered. Surely this is the method of induction; surely this is the mode of reasoning adopted by Darwin and by Newton, and even by Bacon himself. But Sedgwick, great man as he was, almost unrivalled in the field, more brilliant, though less persevering than Lyell, was not always quite free from prejudices; and it may be noted that he more than once stigmatises an opinion which he dislikes by declaring it not to be in accordance with inductive methods. Sir Joseph Hooker's judgment was far more accurate: "One of the most philosophical of geologists, and one of the best of men"†; or that of Charles Darwin himself: "The science of geology is enormously indebted to Lyell—more so, as I believe, than to any other man who ever lived." ‡

* In 1865. "Life and Letters of Sedgwick," ii. p. 412.

† "Life, Letters, and Journal of Sir C. Bunbury," iii. p. 66.

‡ "Life and Letters of C. Darwin," i. p. 76.

Lyell felt a keen interest in the broader aspect of political questions, and this not only in his own country,* though he took little or no share in party struggles, for the vulgarity of the demagogue and the coarseness of the hustings were offensive to a man of such refinement. His opinions harmonised with his scientific habits of thought, always progressive, but never extravagant. He was in favour of greater freedom in education, of the restriction of class privileges, and of an extension of the franchise, but he saw clearly that anything like universal suffrage, as the world is at present constituted, would only mean giving a preponderating influence to those least competent to wield it; that is, to the more ignorant and easily deluded. As in such cases the glib tongue would become more potent than the voice of reason, the demagogue than the statesman, he feared that the standard of national honour would be almost inevitably lowered, and national disaster be a probable result. That all men are equal and entitled to an equal share in the government—a dogma now regarded in some circles as almost sacred—would have been repudiated by him with the quiet scorn of a man who prefers facts to fancies, and inductive reasoning to sentimental rhapsody. A partisan he could not be, for he saw too clearly that in political matters truth and right were seldom a monopoly of any side, and though by no means wanting in a certain quiet and restrained enthusiasm, he had almost an abhorrence of fanaticism. One example may serve for

* He maintained for many years an interesting correspondence with Mr. G. Ticknor, of Boston, U.S.A., in which he often discusses political questions, both British and American.

many, to indicate the way in which he regarded both this spirit and any difficult question. Naturally he had a strong dislike to slavery; he fully recognised the injustice and wrong to the negro, and the evil effects upon the master. Nevertheless, after visiting the Southern States, and giving the impressions of his journey, he thus expresses himself: "The more I reflected on the condition of the slaves, and endeavoured to think on a practical plan for hastening the period of their liberation, the more difficult the subject appeared to me, and the more I felt astonished at the confidence displayed by so many anti-slavery speakers and writers on both sides of the Atlantic. The course pursued by these agitators shows that, next to the positively wicked, the class who are usually called 'well-meaning persons' are the most mischievous in society." He then points out how a strong feeling against slavery had been springing up in Virginia, Kentucky, and Maryland; how the emancipation party had been gaining ground, and slavery steadily retreating southwards, but "from the moment that the abolition movement began, and that missionaries were sent to the Southern States, a reaction was perceived—the planters took the alarm—laws were passed against education—the condition of the slave was worse, and not a few of the planters, by dint of defending their institutions against the arguments and misrepresentations of their assailants, came actually to delude themselves into a belief that slavery was legitimate, wise, and expedient—a positive good in itself." * At a subsequent period he speaks of Mrs. Beecher Stowe's famous book, "Uncle

* "Travels in North America," chap. ix.

Tom's Cabin," as "a gross caricature." But in the great struggle between the Northern and Southern States, his sympathies went with the former. It was the fairness of his criticisms, and his hearty appreciation of the good side in American institutions, that won him many friends and made his books welcome on that side of the Atlantic.

Lyell's views on religious questions accorded, as might be expected, with the general bent of his mind. He was a member of the Church of England,* appreciated its services, the charm of music, and the beauty of architecture, but he failed to understand why nonconformity should entail penalties, whether legal or social. His mind was essentially undogmatic; feeling that certainty was impossible in questions where the ordinary means of verification could not be employed, he abstained from speculation and shrank from formulating his ideas, even when he was convinced of their general truth.

He was content, however, to believe where he could not prove, and to trust, not faintly, the larger hope. So he worked on in calm confidence that the honest searcher after truth would never go far astray, and that the God of Nature and of Revelation was one. He sought in this life to follow the way of righteousness, justice, and goodness, and he died in the hope of immortality.

As he disapproved of any approach to persecution on the ground of religion, so he objected strongly to

* In the later part of his life he appears to have sympathised more with the "Unitarians," for he attended the services at Dr. Martineau's chapel in Little Portland Street, though I am not aware that he formally seceded from the Church of England.

the exclusive privileges which in his day were enjoyed by the Church of England, especially to its virtual monopoly of education. On this point he several times expresses himself in forcible terms; as, for instance, in these words: "The Church of England ascendency is really the power which is oppressive here, and not the monarchy, nor the aristocracy. Perhaps I feel it too sensitively as a scientific man, since our Puseyites have excluded physical science from Oxford. They are wise in their generation. The abject deference to authority advocated conscientiously by them can never survive a sound philosophical education."* To this party—or to the "Catholic movement," as it is now often called—in the Church of England, Lyell had a strong dislike; he deemed their claims to authority unwarrantable, their practices in many respects either childish or superstitious.

As we have endeavoured to bring out in the course of this volume the guiding principles of Lyell's work, a brief recapitulation only is needed as a conclusion. That work was regulated by two maxims: the one, "Go and see"; the other, "Prefer reason to authority." To the first maxim he gave expression more than once, while he was always inculcating it by example. Imitating the well-known saying of Demosthenes in regard to oratory, he emphatically

* Life, Letters, and Journals, vol. ii. pp. 82–127. It must however, be remembered that the High Church party were not alone in their opposition; indeed, after a time, they were more tolerant of geologists than the extreme "Evangelical" school. I have some cuttings from the *Record* newspaper, dated about 1876, which are interesting examples of narrow-minded ignorance and theological arrogance.

declares that in order to form comprehensive views of the globe, the first, the second, and the third requisite is "travel."* What he preached, he practised; about a quarter of the last fifty years of his life must have so been spent. Of the second maxim also he was a living example. It was his practice not only to see for himself, but also to judge for himself, in all questions other than those necessarily reserved for specialists; his rule, that thought should be free from the fear of man, but subject to the laws of reasoning. As a young man he had advocated, almost single-handed, scientific views which were unpopular alike with the older authorities in geology and with the supposed friends of religion; he had protested against the invocation of catastrophic destruction and cataclysmal flood in order to clear away difficulties in the past history of the earth; in other words, against an appeal to miracle, when a cause could be found in the existing order of Nature; and he had disputed the right of any priesthood, whether Romanist or Protestant, to hold the keys of knowledge. He vindicated, against all comers, his claim—nay, his birthright—to sit, as an earnest student, at the feet of Nature to listen and to learn, as she chose to teach, whether by the acted drama of the living world or by the silent record of the rocks. He was, in short, more observer than theorist, more philosopher than poet, more a servant of reason than a dreamer of dreams.

His example is one well worthy of remembrance at the present epoch. The "whirligig of time" has brought its revenges, and has introduced into geology

* Life, Letters, and Journal, i. p. 233. "Principles," i. 69 (eleventh edition).

a class of students almost unknown in the days when Lyell was in his vigour. The developments of mineralogy and palæontology, helpful and valuable as they have been by making geology more of an exact science and, in some cases, substituting order for confusion, have tended to produce students very familiar with the apparatus of a laboratory or the collections of a museum, but not with the face of the earth. This, in itself, would not be necessarily hurtful, because the field of geology is so wide that there is room for all; but it leads sometimes to an undue exaltation of trifles, to an over-estimation of the "mint, anise, and cummin" of science, to a waste of time upon what is called the literature of the subject. This last often means either searching much chaff for a few grains of wheat, or spending much labour with the hope of discovering whether A or B was the first to confer a name upon a species; the priority perhaps being only of a few months, and that name neither particularly appropriate nor euphonious. Partly from this, partly from other causes, the importance, nay, the absolute necessity of travel, for the education of a geologist is now too often forgotten. In this science there are many questions — some of them almost fundamental—for which no perquisitions in a library, no research in a laboratory, no studies in a museum, however conscientiously patient and painstaking they may be, can be accepted as an adequate preparation; questions in which Nature is at once the best book, the best laboratory, and the best museum, and experience is the only safe teacher. What would Lyell have said to men—and such might now be named —who undertook to discuss wide geological problems

with the most limited experience; who, for example, posed as authorities upon what ice can or cannot do, without having even seen a glacier; or speculated on the most intricate questions in petrology without having studied more than some corner of this island, or, indeed, without any precise knowledge of that? Would not he—averse as he was to speaking severely—have censured them for talking about things which they could not possibly understand, and for darkening counsel by words without knowledge?

Lyell, no doubt, had exceptionally favourable opportunities. The eldest son of a wealthy man—who contentedly acquiesced in his seeking fame rather than fortune, and supplied him with the necessary funds—his time was his own, as he had not only enough for his ordinary wants, but also could afford to travel as much as he desired. His social position was sufficiently good to facilitate his access to those who had already attained to eminence. He was blessed with a sympathetic and helpful wife, and they had no children. Thus they were perfectly free, both in the disposal of their time at home and in their peregrinations abroad. Besides these things they both enjoyed good health. Lyell's constitution was not, indeed, so robust that he could take liberties; he had to be careful about "cakes and ale," and to lead a fairly regular life,* but by so doing he was able to be always in good condition for his work. His eyes, in fact, were his only trouble; and who is there who has not

* He admits that when Lord Enniskillen and Murchison had seduced him, after a Geological Society meeting, to partake of pterodactyl (woodcock) pie and drink punch into the small hours, his work suffered for four or five days afterwards.

got his own "thorn in the flesh"? Lyell also was happy in all his domestic relations. His letters indicate that all the family—on both sides—were on affectionate terms, and contain few references to anxieties and troubles, such as the sickness and death of those dear to him, until his life approached the period when such trials become inevitable.

Thus free from the impediments which have beset many other men of marked ability, such as weak health and physical suffering, the wearing anxiety of an invalid wife or a sickly family, the harassing cares of pecuniary losses or of an insufficient income, Lyell had an exceptional chance. But other men have the same and do not use it; they are crippled by this burden or diverted by that allurement, and "might have been" too often becomes their epitaph. Lyell never faltered in the course which, comparatively early in life, he had marked out for himself. With that steady persistency and quiet energy which are characteristic of the Lowland Scot, he put aside all temptations and everything which threatened to interfere with his work. While neither recluse nor hermit, neither churlish nor unsociable, nay, while thoroughly enjoying witty and intellectual society, he allowed nothing to distract him from his main purpose. Convinced that there was a work which he could do, and a name which he could win, he was willing, for sake of this, to run risks and to make sacrifices. He did not indeed despise fame, but he never condescended to unworthy arts to obtain it; he held that the labourer was worthy of his hire, but with him it was always "the work first, and the wage second," whether that were coined gold or laurel

wreath. He was singularly free from all petty jealousies, and ready to learn from all who could teach him anything, but he was no weakling, swayed by every breath of wind, for he reached his conclusions slowly and cautiously, and never stopped to ask whether they would be popular. "Forward, for truth's sake," that was the motto of his life.

In yet another way was Lyell *felix opportunitate vitæ*. In his days, geology might be compared to a country which had been for some time discovered but was not yet explored. Settlements had been established here and there; in their neighbourhood some ground had been cleared, and a firm base of operations had been secured, but around and beyond was the virgin forest, the untrodden land. At almost every step the traveller met with some fresh accession to his knowledge or a new problem to solve. He could feel the allurement of expectation or the joy of discovery even in countries otherwise well known; where now he can hope only to pick up some tiny detail or to plunge into some interminable controversy. If he now desires "fresh fields and pastures new," he must wander beyond the limits of civilised lands; for within these every crag is hammer-marked, and the official geologist is at work making maps. But not only this, Lyell lived in the days when the literature of his science was of very modest dimensions. This had its obvious drawbacks, but it had also its advantages, which, perhaps, were more than compensations. At the present day the conscientious student is in danger of being overwhelmed by the mass of papers, pamphlets and books, from all lands and in all languages—which he is expected, if not to read,

at least to scramble through before venturing to write on any subject. Fifty years ago it required a very limited amount of study—often only a few hours' research—to put the geologist in possession of all that was known, so that he approached his theme very much as a mathematician attacks a problem. This burden of scientific literature, seeing that life is short and human strength is limited, threatens to stifle the progress of science itself, and we can hardly venture to expect that any more great generalisations will be made in geology or palæontology, unless a man arise who is daring enough to subordinate reading to thinking, and so strong in his grasp of principles that he can make light of details.

It has been sometimes said that Lyell was not an original thinker. Possibly not; *vixere fortes ante Agamemnona* is true in science no less than in national history; there were mathematicians before Newton, philosophic naturalists before Darwin, geologists before Lyell. He did not claim to have discovered the principle of uniformity. He tells us himself what had been done by his predecessors in Italy and in Scotland: but he scattered the mists of error and illusion, he placed the idea upon a firm and logical basis; in a word, he found uniformitarianism an hypothesis, and he left it a theory. That surely is a more solid gift to science, a better claim to greatness, than any number of brilliant guesses and fancies, which, after coruscating for a brief season to the amazement of a gaping crowd, explode into darkness, and are no more seen. But to a certain extent Lyell has thrown his own work into the shade. The fame of his books causes his numerous scientific

papers* to be overlooked; particularly his contributions to the history of coalfields and to the classification of the Tertiary deposits. Moreover, into these books he was constantly incorporating new and original matter. We may be fairly familiar with the "Principles" and the "Elements," but we fail to realise until we have read his "Life" and the accounts of his two tours in America how much those books are made up from the results of actual experience and personal study in the field.

It has been also said that Lyell carried the principle of "uniformity" a little too far. But, suppose we concede this, does it amount to more than the admission that he was human? It is almost inevitable that the discoverer or prophet of a great truth, who has to encounter the storm and stress of controversy, should state his case a little too strongly, or should overlook some minor limitation. Suppose we grant that Lyell was a little too lavish in his estimate of the time at the disposal of geologists. The physicist had not then intervened, with arguments drawn from his own science, to insist that neither earth nor sun can reckon their years by myriads of myriads, and even now this controversy cannot be regarded as closed. Suppose we grant that in accepting Hutton's dictum, "I find in the earth no signs of a beginning," Lyell was misled by appearances,† which have since proved to be delusive, and that facts, so far as they go, point rather in the contrary direction. Well, this point

* These were about seventy-six in number, the great majority written prior to the last twenty years of his life.

† Such as the seeming intercalation of crystalline schists with fossiliferous rocks, or the immediate sequence of the two.

also is not yet to be regarded as settled; and of one thing, at any rate, we may be sure, that if Lyell were now living he would frankly recognise new facts, as soon as they were established, and would not shrink from any modification of his theory which these might demand. Great as were his services to geology, this, perhaps, is even greater—for the lesson applies to all sciences and to all seekers after knowledge—that his career, from first to last, was the manifestation of a judicial mind, of a noble spirit, raised far above all party passions and petty considerations, of an intellect great in itself, but greater still in its grand humility; that he was a man to whom truth was as the 'pearl of price,' worthy of the devotion and, if need be, the sacrifice of a life.

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